EXHIBIT 9

In re Flint Water Cases,
No. 16-cv-1044

Supplemental Report of Dr. Larry L. Russell

October 18, 2022

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1 Introduction

This supplemental report to my original report submitted in June 2020, updates information on my assessment of the Corrosion Control Optimization study conducted for the City of Detroit and on additional sampling and observations made at two homes in Flint.

I made a visit to Flint to collect pipe samples from 119 Grace and 1019 Montclair on February 9th 2022 and the results from my observations are reported below. Due to widespread existence of the Covid 19 vaccines and the reduction in infections, it appeared to be unsafe to travel to Flint before February 8th 2022 to visit the homes evaluated by the defense, namely 119 Grace Street and 1910 Montclair. The condition of the piping in each of these homes is reported on below in the section titled Field Work Conducted in February 2022.

My prior reports addressed the failure of Veolia and LAN to fulfill their professional obligations in the engineering services they provided to the City of Flint. In my professional opinion, both firms could and would have prevented the Flint Water Crisis had they performed their services in a manner that comported with the practices of a reasonable engineer. During the course of its work, LAN could and should have identified the need for an effective corrosion control methodology, and noted that the absence of such a methodology presented a tremendous threat to the health and property of people throughout the City of Flint.

Veolia and its engineers provided the last hope to avert the Flint Water Crisis, but Veolia dropped the ball and failed to take the steps any reasonably competent engineer or engineering firm would have taken to protect the health and property of Flint residents. As a threshold matter, the presence of an effective corrosion control methodology is critical for any water distribution system, and particularly so in a system with lead service laterals and the likelihood of corrosive water conditions. Based on the testimony of the Veolia engineers and managers involved with Flint, Veolia knew that Flint water was highly corrosive, and knew or should have known that Flint had no effective corrosion control system in place.

Yet Veolia validated the City's decision to continue operations at the Flint Water Treatment plant based on the conclusions set forth in its report. Veolia also failed to identify the deficiencies in LAN's prior services for the City of Flint, and particularly the fact that it had not ensured that an effective corrosion control methodology was in place. Veolia was also well aware that the best and safest way to protect the health and safety of people in Flint was to remain with the Detroit Water and Sewage Department (DWSD) absent an effective corrosion control system at the Flint Water Treatment Plant, as was ultimately done. While Mr. Ambrose may have said that he was unwilling to approve remaining with DWSD, he did so based on Veolia's advice and Veolia was the engineering firm that should have known better. Further, switching back to the DWSD is exactly the solution that was used at Flint when Mr. Nick Pizzi and Mr. John Young brokered the deal to allow Flint to return to the DWSD water.

2 Opinions

S-1 Both LAN and Veolia should have been aware of, and absorbed, the information in the Tucker, Young, Jackson, Tull, Inc.(TYJT)/CH2M Hill, Inc./Economic and Engineering Services Inc. comprehensive study and report conducted in the early 1990's for DWSD. This report was conducted to ensure that the DWSD water was safe to drink and was in compliance with the Lead and Copper Rule requirements of the Safe Drinking Water Act (SDWA) (Flint was considered to be in the DWSD distribution system at that time).

Basis: Detailed technical evaluation of the TYJT report and review of the DWSD Consumer Confidence Reports

S-2 As demonstrated in this report, essentially all of the homes in Flint (37,000) were built before 1985 when high lead solder was still in use and the homes with copper pipes have substantial amounts of leaded solder and are connected to high lead valves and faucets throughout Flint. Over 60 percent of Flint homes were built before 1945 when lead service laterals were still in common use.

Basis: Section 3 of this report

S-3 By focusing on two homes of named plaintiffs, namely 119 Grace St and 1019 Montclair, the defendants artificially narrowed the useful data collected during their field work. To be consistent with the defense focus, I chose to remove pipe sections from those same houses to avoid adding even more variables into the data being collected. Reviewing the pipes from two homes provides infinitely more information/data than was collected during the defense review of these homes, as the interior of the pipes can be observed and analytical measured.

Basis: Section 3 of this report

S-4 The Detroit Water and Sewage Department's ortho phosphate addition corrosion treatment regime was (and is) very effective at minimizing corrosion of copper pipes in Flint. The effective corrosion rate of the DWSD water in the copper pipes observed was substantially less than the 0.0005 inches (0.5 mils) per year utilized by the Copper Development Association (CDA) in their 50 year warranty for copper pipe.

Basis: Measurements and observations reported on Table 3.1.1

S-5 The copper pipes at 119 Grace were reportedly installed in 2008 during a plumbing remodel and, as such, they were assembled without leaded solder. These pipes were however impacted by the corrosive water served during the Flint Water Crisis losing approximately 0.002 inches of their wall thickness.

Basis: Measurements and observations reported on Table 3.1.1

S-6 The steel pipes at 1019 Montclair were impacted severely during the exposure to the corrosive water during the Flint Water Crisis. These pipes experienced through wall pitting and were down to paper thin remaining wall thickness in many locations at the time that I removed them.

Basis: Measurements and observations reported on Table 5.2.1

S-7 Exposure to the corrosive water distributed during the Flint Water Crisis substantially compromised the life span of the steel pipes in Flint. Just as the steel pipe service laterals were removed by the City and replaced with copper, the steel pipes within these houses require replacement to halt exposure to the lead containing scale accumulated over many years from their lead service laterals. The Flint Water Crisis made these lead scales more readily exposed due the aggressive Flint River water attack on these scales. Replacement is required to provide the residents with a plumbing life span required to service these homes in the future without catastrophic leakage and failure in the future.

Basis: Measurements and observations reported on Table 5.2.1

S-8 Based on the work of Dr. Marc Edwards in 2015, the steel pipes in Flint were rapidly aged by the distributed Flint River water. The treated Flint River water was more than 8.5 times more corrosive than the DWSD water resulting in the pipes experiencing over 11 years of additional corrosion damage in the 16 months during the Flint Water Crisis. The resulting damage is a direct analogy to the "straw that broke the camel's back" rendering the homes to require full pipe replacement.

Basis: Reference 2

S-9 If LAN and/or Veolia had insisted on the addition of orthophosphate, while they were retained by the City of Flint, the impact of the accelerated corrosion to the residential and business pipes that occurred during the period when treated Flint River was distributed could have been minimized.

Basis: Knowledge of the water chemistry and corrosive nature of the treated Flint River Water.

S-10 The copper pipes at 1019 Montclair were impacted by the corrosive water served during the Flint Water Crisis losing approximately 0.006 inches of the wall thickness of the pipe most likely during that period when orthophosphate was not added.

Basis: Measurements and observations reported on Table 5.2.1

S-11 The lead levels remaining in the heavily corroded and tuberculated steel pipe sections collected from 1019 Montclair (and most likely at all other similarly plumbed homes having water service laterals made from lead) are excessive and present a risk that can only be addressed by complete re-plumbing due to the severity of the corrosion damage, pitting of these pipes, and

the high levels of lead remaining in the pipe scale. Due to their age, and as was demonstrated by the defense data collection with an XRF, the brass faucets and valves in these homes have high lead content which exceed the current standards for lead content by up to two orders of magnitude and likewise require removal and updating with fixtures that meet the current less than 0.25 percent lead requirement.

Basis: Measurements and observations reported on Table 5.2.1

S-12 The condition of the residual scale that remains in the pipes today, with the high lead content, is a problem that needs to be corrected immediately.

Basis: Measurements and observations reported on Table 5.2.1

3 Flint Homes

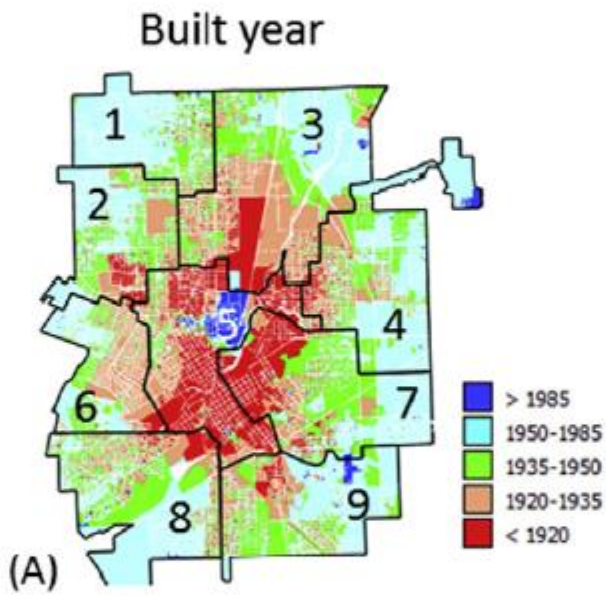
The tables shown below report the time period when homes were constructed and the associated percentage of properties in Flint constructed during that period The figure presented below shows a color-coded map showing the age of homes and their locations. The homes in the center of the City, colored in red (pre 1920 construction), are also many of the homes with lead service laterals. In general, lead service laterals would have been used in homes constructed before 1945 (60 percent of the Flint homes). The vast majority of the Flint homes were built before copper pipe was widely used (1960) and nearly all the homes (99%) were constructed before non-leaded solders were required in 1986. Therefore, these homes either contain steel pipes with lead in their scales or copper pipes connected with high lead solder. In either case, the only cure is to perform a complete repiping of these homes and to update their valves and faucets to remove the high lead brass in the faucets.

The tables and the figures are included to demonstrate why the two homes, although a very minimal sample of the 37,000 homes in Flint are good examples of homes impacted by the Flint Water Crisis as these homes had lead service laterals and were impacted with poor water quality and corrosive water during the Flint Water Crisis

Table 3.1: Age of homes in Flint based on parcel data. Approximately 60 percent of homes were constructed prior to 1945 and 99 percent of homes were constructed prior to 1986.

Dates	Quantity	Percentage
Pre-1900	301	0.8%
1901-1910	350	1.0%
1911-1920	3139	8.8%
1921-1930	9015	25.3%
1931-1940	1589	4.5%
1941-1950	5848	16.4%
1951-1960	11060	31.0%
1961-1970	3230	9.1%
1971-1980	757	2.1%
1981-1990	46	0.1%
1991-2000	92	0.3%
2001-2016	243	0.7%

Figure 3.1: Color coded map showing when homes were constructed in Flint. The newest homes (1986-present) are shown in dark blue, whereas the oldest homes (pre 1920) are shown in red. Reproduced from P. Goovaerts / Science of the Total Environment 599-600 (2017) 1552-1563, Figure 3.



Tables from Goovaerts 2017

These additional tables reproduced from Goovaerts work in 2017 are included to demonstrate the widespread the impact of the Flint Water Crisis on typical residential users that make up the Class. This data base was compiled in 2017 and is likely reporting data that doesn't fully show the 28,000+ lead and galvanized service laterals.

Table 3.2: Percentages of lead (LSL) and galvanized (GSL) service lines compared with home age. Source: P. Goovaerts / Science of the Total Environment 599-600 (2017) 1552-1563, Table 3.

Percentages of lead and galvanized service lines found during house inspection for three classes of construction year and the three types of SL material reported in city records. These results were used as soft indicator data in residual kriging.

Digital data	LSLs			GSLs		
	Construction year			Construction year		
	<1938	1938–1951	>1951	<1934	1934–1971	>1971
Lead	1.66	29.0	0.0	10.8	3.79	0.0
Other	0.65	0.45	0.0	46.7	4.20	0.0
Unknown	1.48	19.2	0.0	63.1	4.30	0.0

Table 3.3: Percentages of lead (LSL) and galvanized (GSL) service lines compared with ward and home age. Note the high percentage of homes constructed pre-1951. Source: P. Goovaerts / Science of the Total Environment 599-600 (2017) 1552-1563, Table 2.

Numbers of parcels and statistics on MDEQ inspection results and housing characteristics within each ward in Flint. Poverty level represents the percentage of the block group population living in households where the income is less than or equal to twice the federal "poverty level".

Statistics	Flint ward								
	1	2	3	4	5	6	7	8	9
Total number of parcels	6564	6682	8092	5941	7382	4996	5230	6058	5094
Number of inspections	154	348	211	266	218	427	615	532	483
% parcels inspected	2.34	5.21	2.61	4.48	2.95	8.55	11.8	8.78	9.48
% LSLs (field data)	0.0	3.45	2.37	1.50	0.46	6.79	4.88	3.38	7.45
% GSLs (field data)	7.79	11.5	28.4	9.40	28.4	12.7	19.0	22.2	21.7
% pre-1934 houses	13.1	27.5	56.6	35.6	82.4	50.2	39.0	35.1	36.3
% 1938–1951 houses	27.6	36.1	14.5	19.8	6.35	24.4	25.5	20.4	27.4
% LSLs (digital data)	3.40	8.25	8.85	5.44	10.8	9.45	6.31	7.35	7.03
Block group poverty level (%)	66.3	63.0	74.7	65.0	73.6	67.1	57.6	59.4	65.1

Table 3.4: Percentages of lead (LSL) and galvanized (GSL) service lines identified as of 2017. Note the high percentage of homes constructed pre-1960 (88%). Source: P. Goovaerts / Science of the Total Environment 599-600 (2017) 1552-1563, Table 4.

	Parcels
Total number	51,045
Service lines (%)	
Lead	7.32
Other	69.19
Unknown	23.49
Built year (%)	
<1940	47.46
1940–1959	41.56
≥1960	10.98

4 1994 DWSD Copper Corrosion Control Optimization Study

Veolia had been working at DWSD since 2014. Their work in Detroit continued during their time of their engagement in Flint, and it is inconceivable that the Veolia engineers were not familiar with the Optimized Corrosion Control Treatment (OCCT) at Detroit. In fact, Veolia water quality engineer Marvin Gnagy testified on December 12, 2019 (29:16 and 30:14) that he personally reviewed the DWSD corrosion control program on behalf of Veolia for their work at Detroit. The DWSD study was prepared by Tucker, Young, Jackson, Tull, Inc. (TYJT) in association with CH2M Hill, Inc. and Economic and Engineering Services Inc. in May of 1994 for DWSD (and most likely the contents of this corrosion control report). It is important to realize that the approach utilized by the TYJT team is a picture-perfect example of what is industry standard today (and an example of truly outstanding work for 1994).

In Gnagy's deposition (30:14) he incorrectly stated that the DWSD adjusts the pH and alkalinity and that they add orthophosphate, perhaps indicating that he did not really evaluate the DWSD OCCT program, and DWSD only adds orthophosphate and does not adjust the alkalinity and pH except through a minimal lowering, due to the water treatment chemical addition.

Most importantly, failure to follow the plan laid out by the TYJT team in 1994 lead to a fatal flaw in Veolia's and LAN's assessment of the problems in Flint. This flaw indicates Veolia's and LAN's failure to meet the Standard of Care when the work that they performed before and/or during the Flint Water Crisis didn't even meet the Standard of Care for work conducted in 1994. The 1994 report was based on pipe loop studies, solid engineering evaluations, a true understanding of the corrosiveness of the treated Lake Huron water, appreciation of the number of lead service laterals, accurate knowledge of the EPA rules and regulations with respect to the Lead and Copper Rule, and water/corrosion chemistry in general, along with the TYJT guidelines and observations for implementing a successful and comprehensive Optimal Corrosion Control Treatment plan for Flint.

Clearly, the Lake Huron and Flint River water sources are substantially different (higher chlorides, etc. in the treated Flint River making it substantially more corrosive than treated Lake Huron water), which served to make the need for having an OCCT at Flint even more urgent than it was for DWSD. The DWSD report should have formed an obvious road map for the engineers at both LAN and Veolia, as many of the issues faced in Detroit are similar to those in Flint (including lead service laterals, old plumbing systems, potentially corrosive water, and the Flint distribution system is considered to be a part of the DWSD system). The Optimized Corrosion Control Program (OCCP) instituted by DWSD should have been the starting point for implementation of the corrosion control program for the treated Flint River water. However, neither Veolia nor LAN followed this path. If LAN or Veolia had followed the work begun by the TYJT team in 1992, LAN and Veolia would have progressed a long way very quickly toward averting the Flint Water Crisis. The DWSD report would have made an excellent road map for LAN and Veolia to guide their work for the City of Flint on water quality engineering, and it is likely that if the LAN and

Veolia professional engineering guidance had been molded with the full knowledge expressed in the 1994 DWSD report, that the Flint Water Crisis would never have occurred.

Based on the work conducted in the TYJT study, and their ongoing work in Detroit, it is inconceivable that Veolia would not have realized the value of adding orthophosphate to minimize corrosion of lead, copper and iron to protect the plumbing systems in the homes and buildings of Flint. The need for orthophosphate is especially critical in light of Veolia's recommendation to increase the chloride in the water by adding more ferric chloride to reduce trihalomethane (THM) precursors, which would have made the treated Flint River water even more corrosive than it already was had the City accepted Veolia's recommendation.

Similarly, it is equally inconceivable that the LAN engineers were not aware of this report written in 1994, and which incorporated the City of Flint as a part of the DWSD distribution system as shown on Figure 4.1.1 (Figure ES -1 from the TYJT report). If both of the City's water quality engineering consultants were unaware of the TYJT OCCP study and report and the DWSD corrosion control program, then they did not adequately conduct their due diligence prior to providing advice to the City of Flint on water quality and it resulted in them both practicing below the requisite Standard of Care.

At the time the TYJT report was written, they indicated that the treated DWSD water was "…moderately corrosive." (Pages ES 3 and ES 4 of the 1994 report). During two rounds of home water quality sampling conducted for that report in 1992, the lead results were 0.017 and 0.023 mg/l (see Figure 4.1.2 - both above the Lead Action Level of 0.015 mg/l). Thus, both rounds of sampling indicated that immediate action would be required to reduce the corrosiveness of the water to protect the plumbing and the user's health as required by the SDWA. While the copper numbers were better, they were not good. The resultant copper results were 0.34 and 0.19 mg/l (see Figure 4.1.3 - the Copper Action Level is 1.3 mg/l), indicating that there was active copper corrosion occurring within the houses in the DWSD distribution system.

The TYJT report correctly summarized the following about the various options for corrosion control treatment (note that in 1992, these first five options were eliminated from further consideration due to the factors listed below (page ES 5) [red emphasis added]:

1) "Polyphosphate – These products are primarily used to sequester iron, calcium and manganese and may actually do more to promote lead corrosion than to prevent it."
2) "Polyphosphate/Orthophosphate Blends – These products have not been proven to be more effective than orthophosphates alone for lead reduction, and their proprietary chemical compositions make selection of the optimum product difficult."
3) "Silicates – Sodium silicate inhibitors require a high dosage for lead control and, based on a survey of major industries, would have significant adverse effects on industrial water users."
4) "Alkalinity Adjustment - This technique would have marginal performance for lead reduction based on DWSD water quality and would be impractical for a system the size of DWSD."
5) "Calcium Adjustment to Deposit a Calcium Carbonate Layer – This technique is not a proven method for lead reduction, and would [sic] be difficult to produce a [sic] uniform layer

throughout a distribution system the size of DWSD. Calcium carbonate deposition, however, can occur when pH is raised for lead reduction. This situation is addressed under pH adjustment alternative."

a. Note: Alternative (5) is lime softening – championed by LAN as the solution to controlling lead corrosion.

Note that the first item rejected for chemical addition for the Flint/DSWD system, Polyphosphate, was recommended by Veolia in 2015 (over 20 years after the TYJT rejected this chemical additional from further consideration), and items 4 and 5 of the rejected alternatives were the basis of the LAN ill-fated recommendations for using water softening as a corrosion control alternative for the Flint River water. Had LAN and Veolia simply followed the approach utilized by the TYJT team in the early 1990's, it is likely that the Flint Water Crisis would never have occurred. It should be noted that even in the 1994 report, it was recognized by the TYJT team that with the levels of lead that were being measured, that a Lead Service Line removal program would likely be required (page ES-4) at a cost that could reach $800,000,000 (1994 USD).

The additives/approaches utilized for further study and recommendation were the following"

1) "Orthophosphates – These products have been shown to be an effective means of lead reduction for water similar to that of the DWSD."
2) "Zinc Orthophosphates – These products are also a proven method of lead reduction, although there is concern about zinc in industrial water and wastewater."
3) "pH Adjustment – This technique is also a proven method of reducing lead solubility, although higher pHs affect some industrial users and can increase calcium carbonate deposition."

Figure 4.1.4 demonstrates the effectiveness of the chosen chemical addition, Orthophosphate, in controlling lead corrosion with the treated Lake Huron water. Figure 4.1.5 demonstrates the effectiveness of the chosen chemical addition, Orthophosphate in controlling copper corrosion with the treated Lake Huron water. After a substantial pipe loop testing of these alternatives, the TYJT team correctly recommended a treatment strategy using phosphoric acid to add orthophosphate at a recommended dose of 1.2 mg/L as P, initially, and reducing it to a sustained dosage of 0.4 mg/L, as the optimal DWSD corrosion control treatment in their 1994 study (ES-9).

The TYJT team also indicated that the cost of dosing with phosphoric acid added an operating cost of <u>$0.87 annually per household in 1994 USD</u> ($1.50 in 2014) which is de minimis in the grand scheme of the cost of the Flint Water Crisis in damage to the residents' plumbing, money, and human health impacts related to the corrosion damage incurred during the Flint Water Crisis. The overall system costs of the various treatment alternatives are shown on Figure 4.1.6.

Figures 4.1.7 and 4.1.8 respectively report the relative performance/effectiveness of various corrosion control strategies and the time that was invested to properly address the development of an OCCT for DWSD (over three years). This information would have been useful for LAN and the City of Flint to recognize how long it takes to properly conduct an OCCT, which should have been a red flag regarding

the proposed switch over data to the Flint River water. One of the tasks accomplished in the 1994 DWSD report was to review all of the corrosion control programs in use by water supply/distribution companies located throughout the Great Lakes, not with an eye to defend what was done as LAN had done, but with an eye towards gaining knowledge to efficiently perform their work. Had LAN incorporated orthophosphate addition during their re-design of the Flint Water Treatment Plant (FWTP) modifications originally, the OCCT evaluation could have been completed while the water was being supplied from the Flint River and the damage to resident and business plumbing would have been substantially reduced and potentially eliminated. Similarly, failure to look into what the neighboring facilities were doing to control corrosion with water of regionally similar water quality, further doomed the work done by LAN and Veolia.

Figure 4.1.9 and Table 4.1.1 present a schematic treatment system layout and the system sizing for a suitable orthophosphate dosing system that LAN could have used in their evaluation and redesign of the FWTP. Through the 1994 TYJT DWSD corrosion control study, LAN was provided with a ready to incorporate plan for corrosion control modification at the FWTP. The TYJT report was written 20 years before the Flint Water Crisis, but was apparently ignored by LAN during their redesign of the FWTP.

Figure 4.1-1: ***DWSD Lead and Copper Corrosion Control Optimization Study (1994),*** **Figure ES-1: DWSD Water System.**

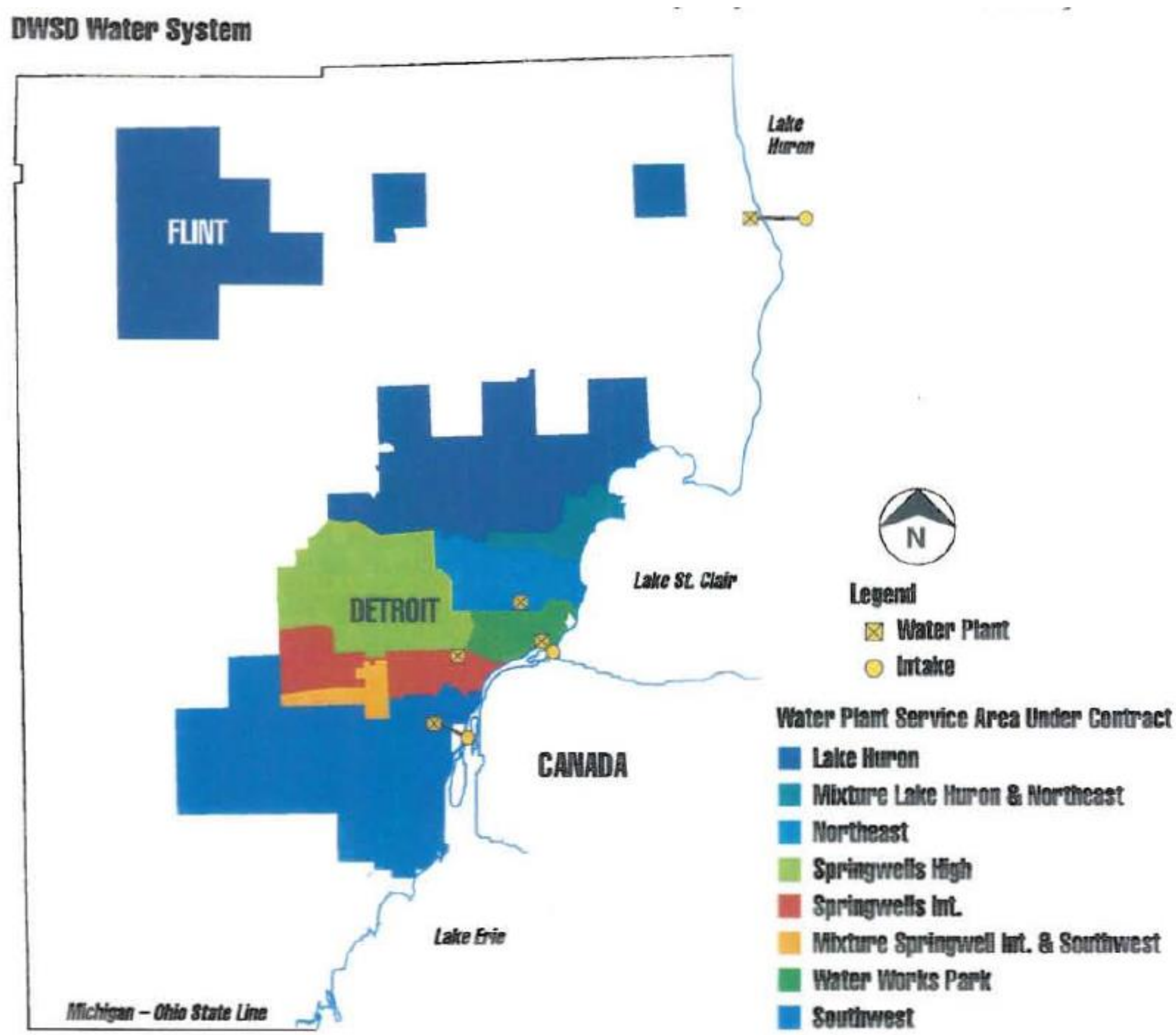


Figure 4.1-2: DWSD Lead and Copper Corrosion Control Optimization Study (1994), Figure ES-2: LCR Compliance Monitoring Results for Lead.

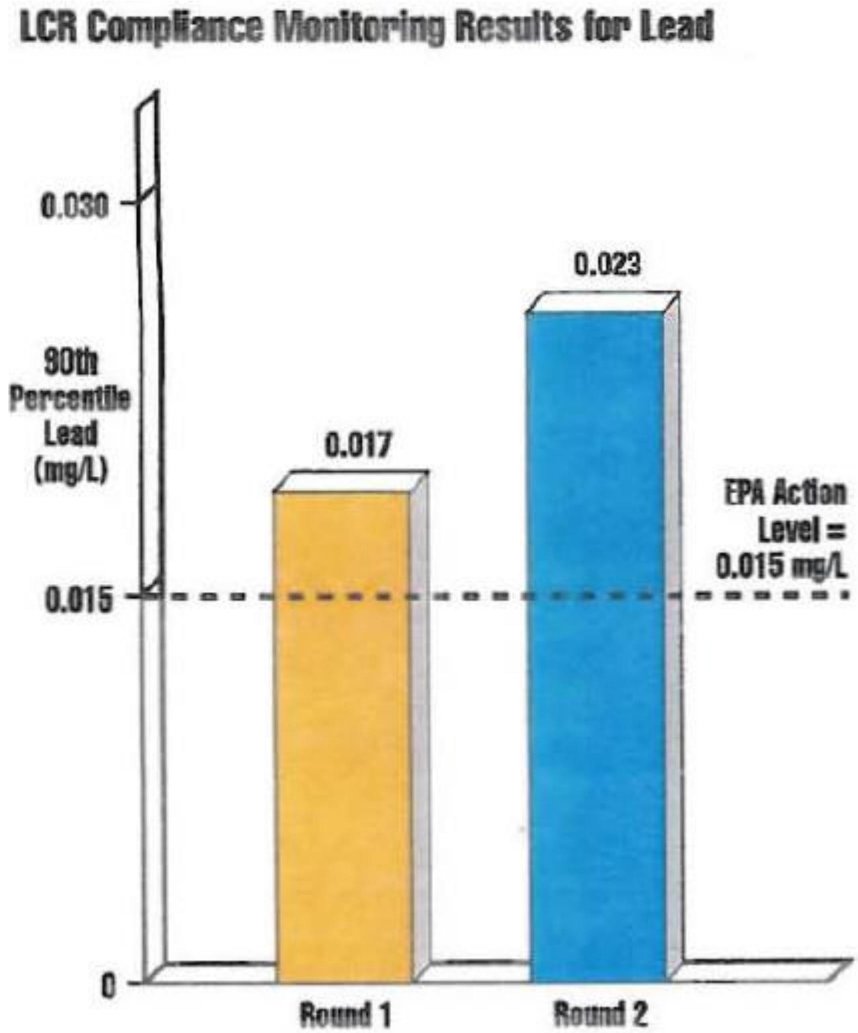


Figure 4.1-3: ***DWSD Lead and Copper Corrosion Control Optimization Study (1994),*** **Figure ES-3: LCR Compliance Monitoring Results for Copper.**

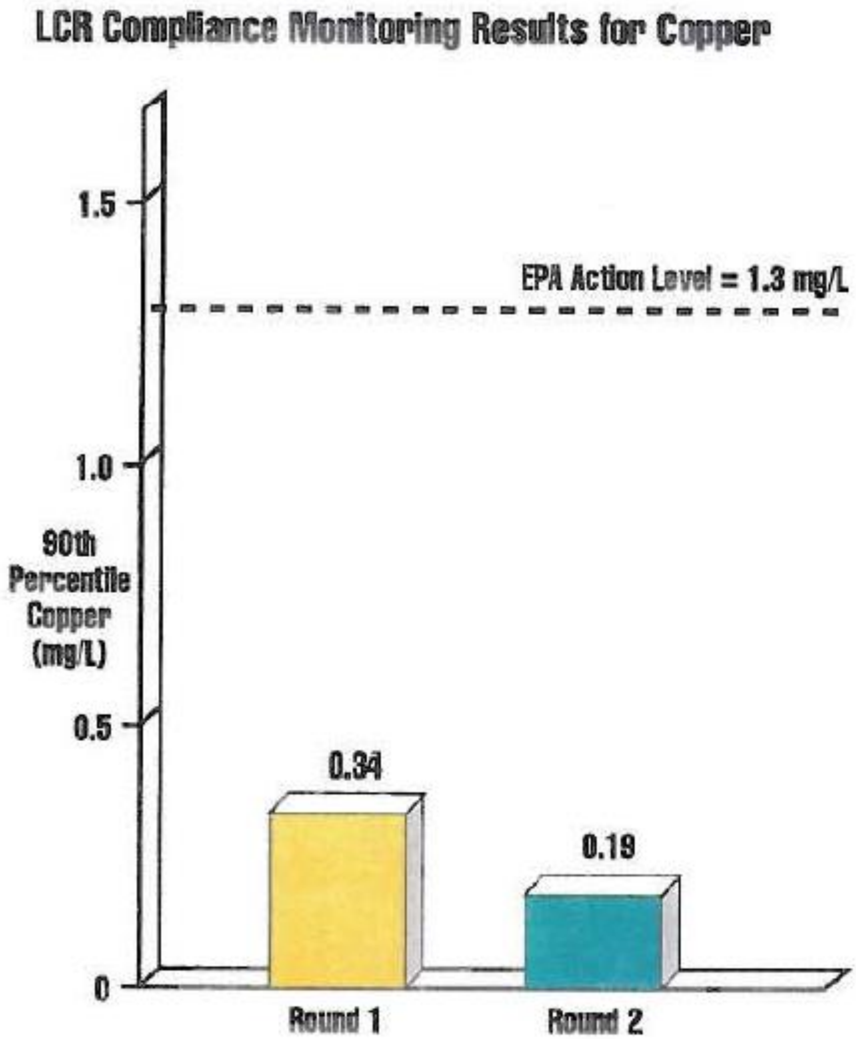
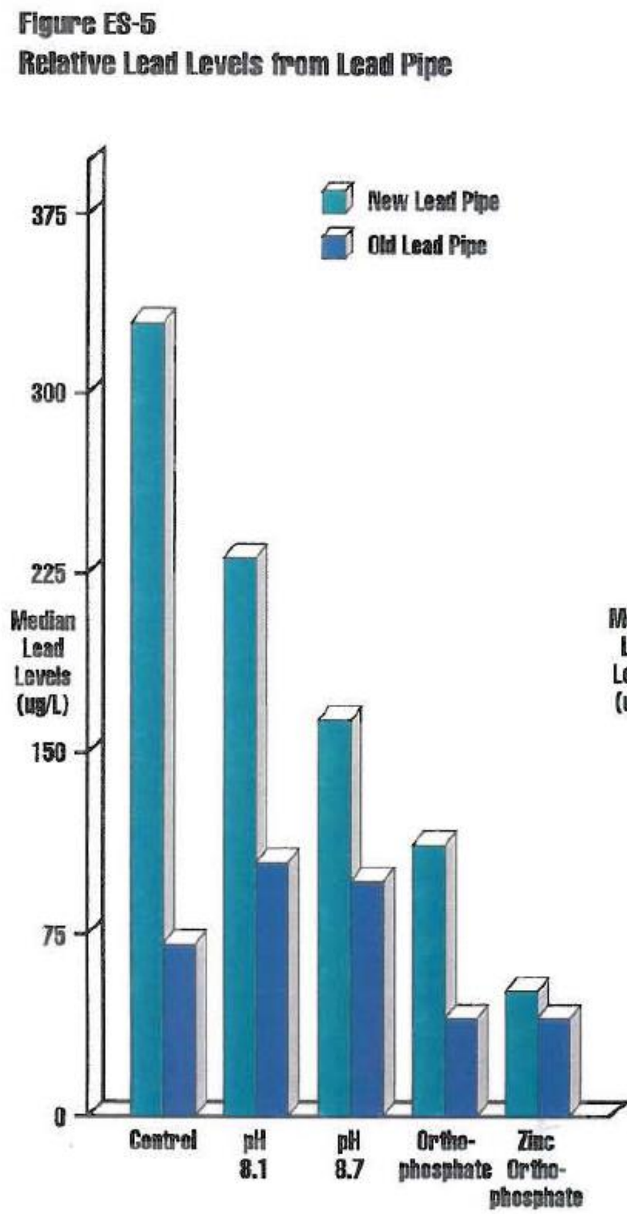


Figure 4.1-4: ***DWSD Lead and Copper Corrosion Control Optimization Study (1994),*** **Figure ES-5 and ES-6: Measured lead levels from lead pipe (left), brass and soldered copper pipe (right) during corrosion control optimization testing.**



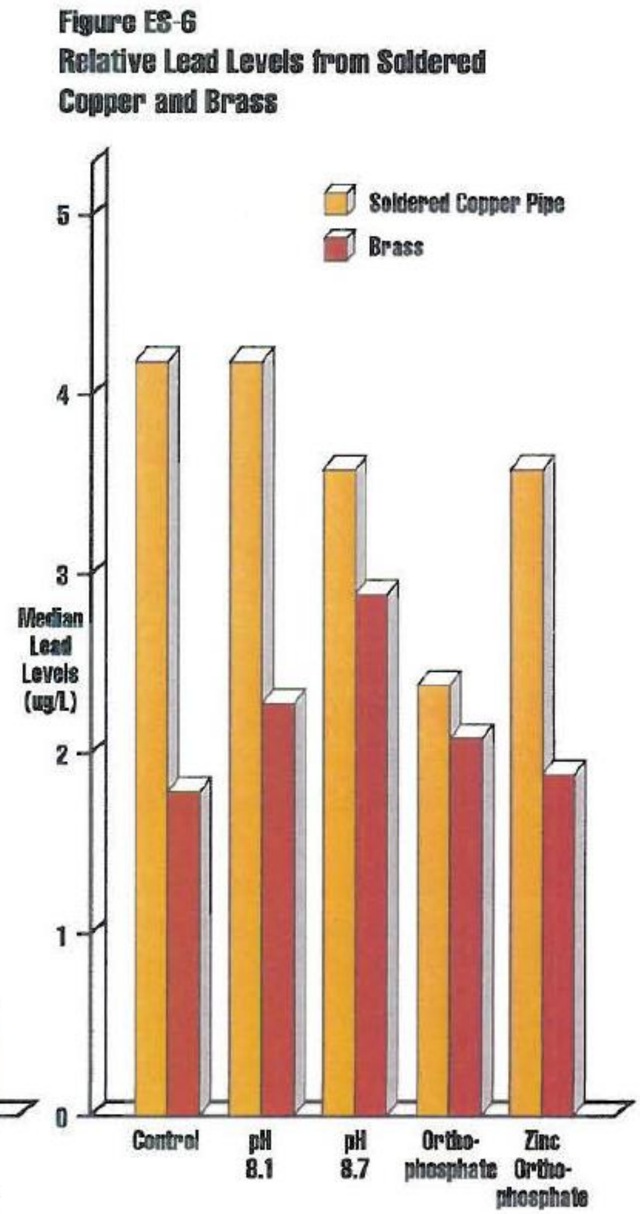


Figure 4.1-5: ***DWSD Lead and Copper Corrosion Control Optimization Study (1994),*** **Figure ES-7: Measured copper levels from copper pipe during corrosion control optimization testing.**

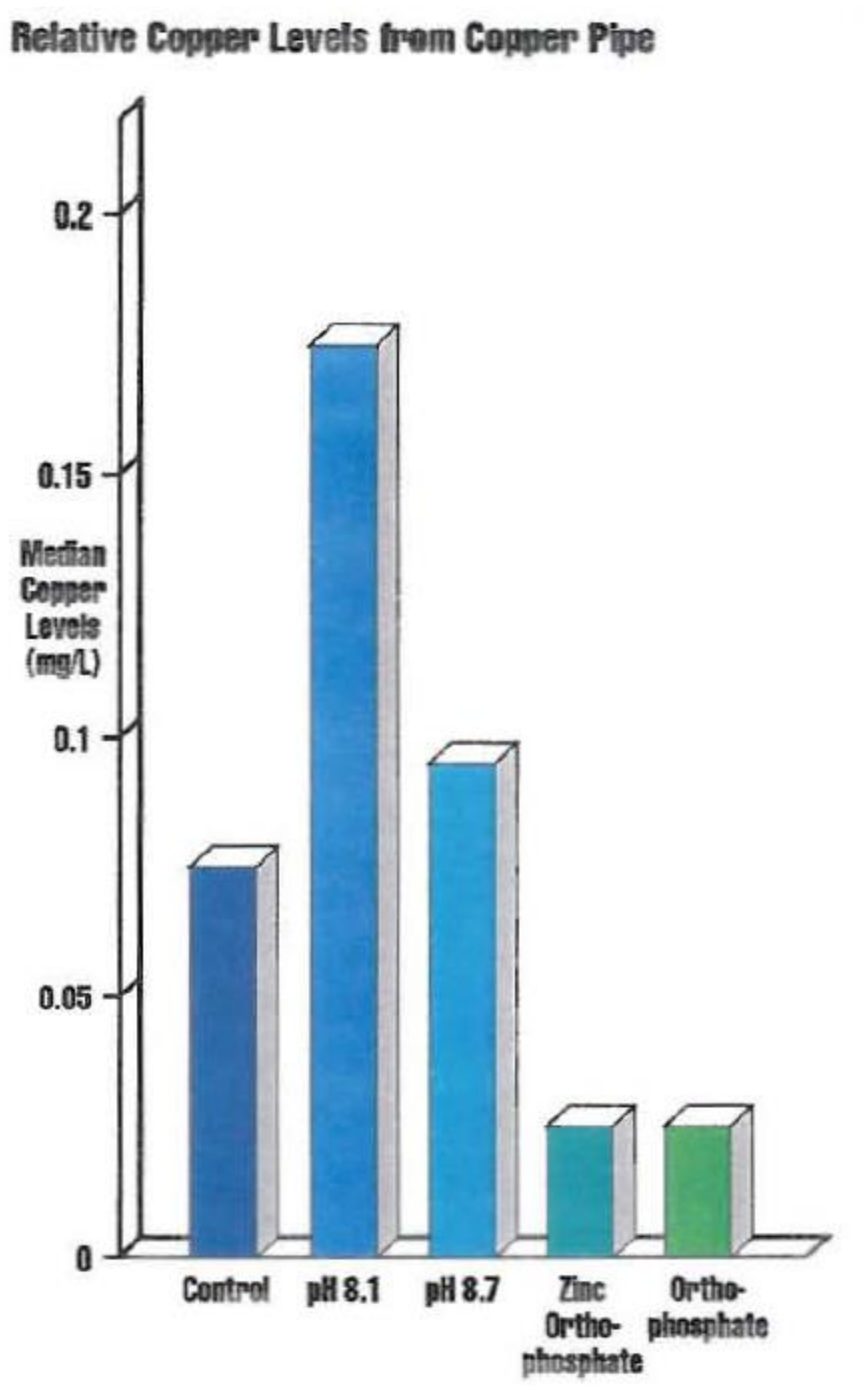


Figure 4.1-6: ***DWSD Lead and Copper Corrosion Control Optimization Study (1994),*** **Figure ES-8: Treatment Alternative Costs.**

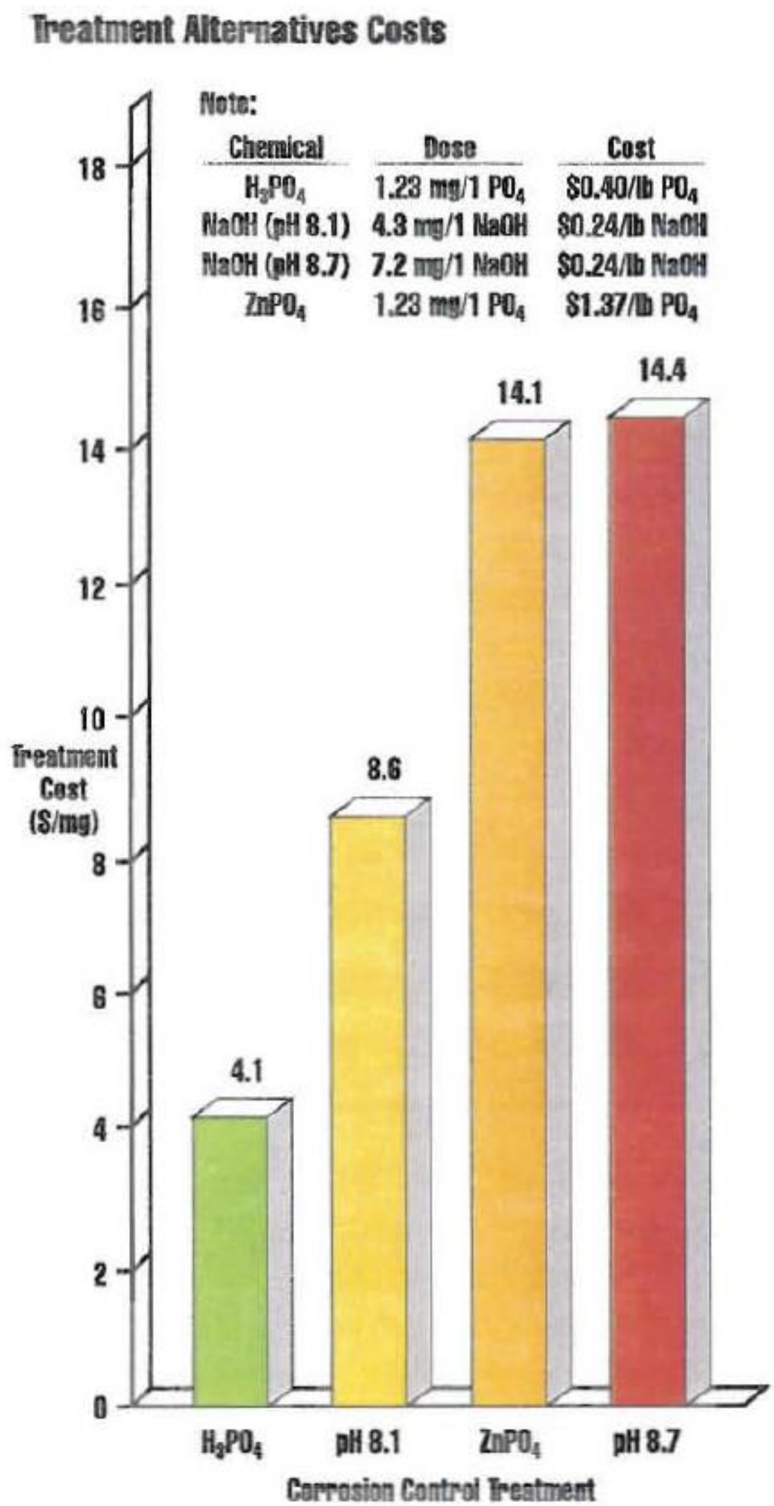


Figure 4.1-7: ***DWSD Lead and Copper Corrosion Control Optimization Study (1994),*** **Figure ES-9: Alternative Ranking by Criteria: lowest score is best.**

Alternatives Ranking by Criteria

	Evaluation Criteria				
Treatment	Performance wt.= 2	Feasibility wt.= 1	Reliability wt.= 1	Cost wt.= 1	Weighted
Phosphoric Acid	2	1	1	1	7
Zinc Orthophosphate	1	4	2	3	11
pH 8.1	4	2	3	2	15
pH 8.7	3	3	4	4	17

Legend: 1 = Best; 4 = Worst

Figure 4.1-8: ***DWSD Lead and Copper Corrosion Control Optimization Study (1994),*** **Figure ES-10: DWSD Corrosion Control Implementation Schedule.**

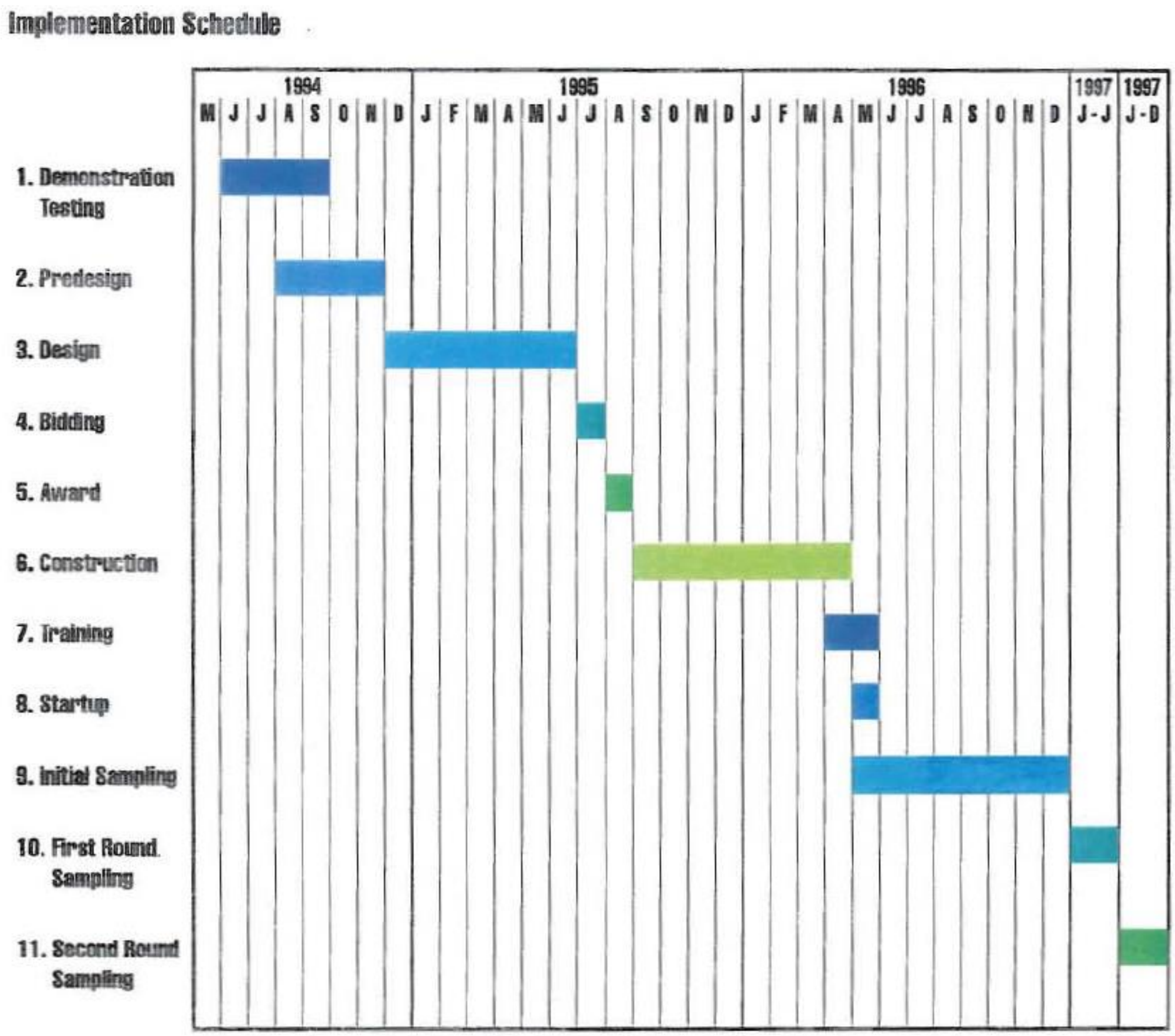
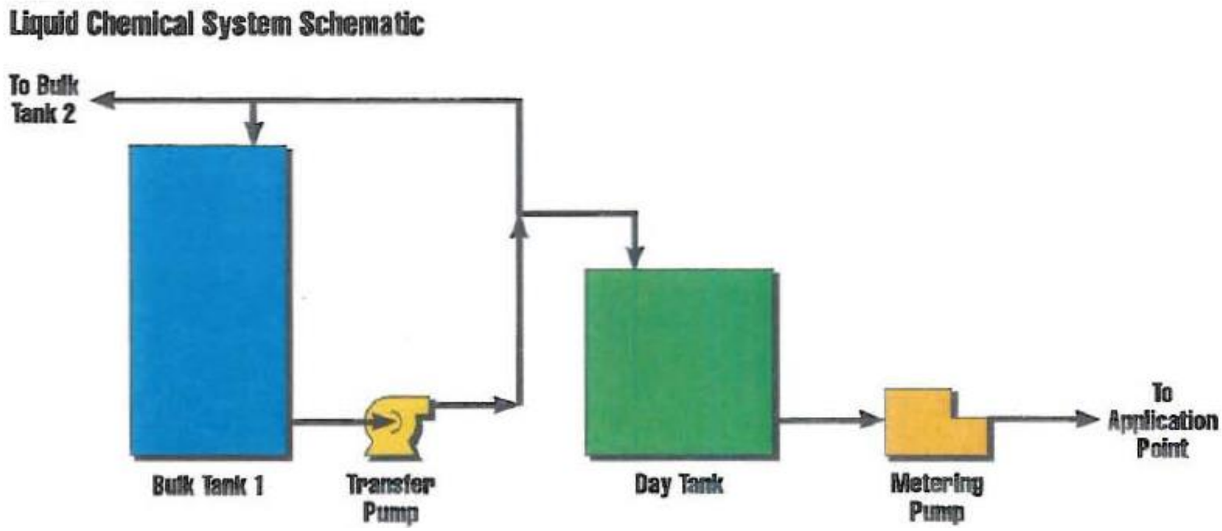


Table 4.1-1: ***DWSD Lead and Copper Corrosion Control Optimization Study (1994),*** **Table ES-1: Chemical Equipment Summary.**

Chemical Equipment Summary	Southwest Water Plant	Water Works Park Water Plant	Northeast Water Plant	Springwells Water Plant	Lake Huron Water Plant
Number of bulk tanks	2	2	2	2	2
Bulk tank capacity, each (gal)	4,000	4,000	4,000	6,000	4,000
Number of day tanks	1	1	1	1	1
Day tank capacity (gal)	200	200	200	400	200
Number of feeders	3	3	3	3	3
Feeder capacity, each (gpd)	1 @ 200 2 @ 650	1 @ 300 2 @ 650	1 @ 250 2 @ 800	1 @ 600 2 @ 1,500	1 @ 350 2 @ 650
Number of transfer pumps	2	2	2	2	2
Transfer pump capacity each (gpm)	15	15	15	30	15

Figure 4.1-9: ***DWSD Lead and Copper Corrosion Control Optimization Study (1994),*** **Figure ES-11: Schematic of Liquid Chemical Feed system for corrosion control chemicals.**



5 Field work conducted in February 2022

5.1 119 Grace St.

During my February 9th, 2022 visit, pipe sections were removed and replumbed to address the obvious deficiency of the defense expert's work wherein they only evaluated the pipes from the outside without ever looking into the remaining pipe wall thickness or internal scale mineral quality. During my site visit the relevant pipe sections identified in the defense report were removed by a licensed plumber for evaluation in our metallurgical laboratory in California.

Pipe sections tested externally by the defense were identified by the photographs taken by the defense experts. These sections were labeled and carefully removed for transport back to California. Approximately 20 pieces of pipe were removed from the two houses and stored and controlled under my supervision.

The removed pieces were then carried by me to our metallurgical laboratory on February 17, 2022, where I selected the segments for visual, microscopic and scanning electron microscopic evaluation. Iron scale was scraped from the interior of the pipe within the steel pipe sections for wet chemistry analysis and then the scale was dissolved in nitric acid and analyzed by ICAPS for lead.

Table 5.1-1: 119 Grace Street Copper Plumbing Testing Results

Item ID	Pipe section	Wall Thickness: [Inches]	Wall Thickness: [Inches Reduction]	Lead [ppm]	Phosphate [% by weight]
A	Cold - Copper tee	0.026*	0.002	Solder: lead free Scale: <1000	1.20 avg– 3 measurements
B	Hot - Copper pipe	0.026*	0.002	Scale: <1,000	1.96 avg – 4 measurements

**Type M copper nominal wall thickness is 0.028 inches*

My observations showed that the both hot and cold copper pipes are Type M copper pipe, that was reportedly installed in 2008 during a replumbing of the home to remove the steel piping, were impacted by the exposure to the corrosive Flint River water during the Flint Water Crisis as evidenced by the reduction in wall thickness measured at our metallurgical laboratory. The copper pipe wall was reduced in thickness to the point that 0.002 inches were dissolved. The corrosion rate between 2008 and 2014 and 2016 to 2022 was substantially less than the 0.5 mil per year warrantied for the life of copper pipe under the Copper Development Association's 50-year warranty indicating that the DWSD corrosion control program did an excellent job of protecting these pipes from 1967 to 2014.

The copper pipe also showed the existence of a phosphate scale likely deposited by the water treatment chemicals added to the water since the Flint Water Crisis occurred. Thus, it is likely that a substantial amount of this wall thickness was dissolved due to corrosion during the Flint Water Crisis, because this pipe was unprotected due to the absence of the orthophosphate addition. When the addition of orthophosphate was terminated in 2014 simultaneously with the distribution of the substantially more corrosive and high chloride level treated Flint River water distributed throughout the Flint water system, it is clear that conditions were ripe for the rapid corrosion of the copper pipes.

Additionally, the average copper corrosion rate experienced by these pipes was substantially less than the corrosion rate experienced during the Flint Water Crisis. The minimal corrosion rate of the DWSD water was achieved in large part due to the efficacy of orthophosphate in controlling uniform copper corrosion. The impact of uniform corrosion is most readily observed due to the uniformity of presence of the greenish copper scale in the copper pipes on all quadrants of the pipe. No evidence of non-uniform corrosion (pitting) was observed in the sectioned pipes, although only a few feet of pipe were sectioned for review and the potential for non-uniform corrosion still exists in the old copper pipe within Flint.

This home was reported built in 1915, the water heater was last replaced after 2011. The antecedent history of the original plumbing system is not documented, although galvanized steel pipe was not installed routinely in homes until after World War II. Galvanized steel pipe was largely abandoned as a construction material by the 1960's in lieu of copper pipe.

Photos of the sectioned pipes taken from this home are presented below. The SEM/EDS spectra are included in the Attachments to this report.

Figure 4.1-1: Pipe sample "A".

Figure 4.1-2: Pipe sample "A", sectioned.

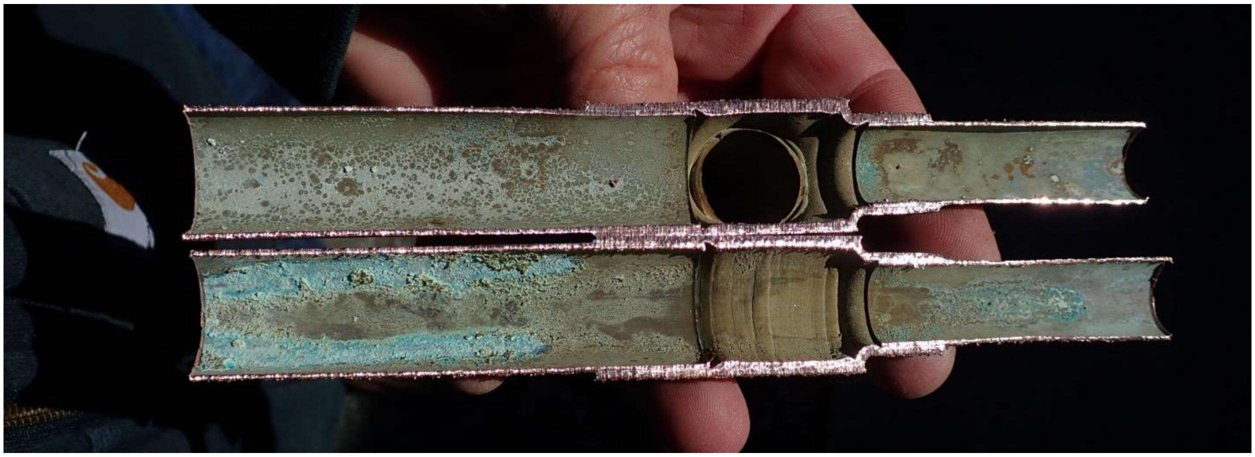


Figure 4.1-3: Pipe sample "B".

Figure 4.1-4: Pipe sample "B", sectioned.

5.2 1910 Montclair

This house was visited on February 9th (2022). During this visit, steel and copper pipe sections were removed and replumbed to address the obvious deficiency of the defense expert's work, wherein they only evaluated the pipes from the outside at this house without ever looking into the remaining pipe wall thickness or interior scale mineral quality. During my site visit the relevant pipe sections were removed by a licensed plumber for evaluation in our metallurgical laboratory in California.

Pipe sections that had been tested externally by the defense experts were identified by the photographs taken by those experts. These pipe sections were labeled and carefully removed for shipment back to California with me. Approximately 20 pieces of pipe were removed from the two houses and stored and controlled under my supervision.

The removed pieces were then carried by me to our metallurgical laboratory on February 17, 2022, where I selected the segments for visual, microscopic and scanning electron microscopic evaluation. The iron scale was scraped from the interior of the pipe within the steel pipe sections. The scale was then dissolved in nitric acid and analyzed by ICAPS for lead.

Table 5.2-1: 1910 Montclair Plumbing Testing Results

Item ID	Pipe section	Wall Thickness: [Inches]	Wall Thickness: [inches of wall thickness dissolved]	Lead [ppm]	Phosphate [% by weight]
E	Hot – copper pipe to the water heater	0.019*	0.006	Solder: lead free Scale: <1,000	3.97 avg % – 4 measurements
F	Cold – copper pipe to the water heater	0.026*	0.002	Solder: lead free Scale: <1,000	1.96 avg %– 4 measurements
G	Steel pipe tee – corroded through	0.000	0.1	Scale: 41.8 ppm	2.46 avg %– 4 measurements
H	Steel pipe elbow – corroded through	0.000	0.1	Scale: 168 ppm	0.93 avg %–4 measurements
I	Steel nipple and elbow – corroded through	0.000	0.1	Scale: 83.3 ppm	2.48 avg %– 6 measurements

**Type M copper nominal wall thickness is 0.028 inches/1/2 inch steel pipe wall thickness is 0.1 inches*

The copper plumbing was likely installed between 1960 and 2014. The steel pipe sections were "holding on by the thinnest of margins", and it appears that exposure to corrosive Flint River water during the Flint Water Crisis pushed these pipes to the brink of failure as evidenced by the reduction in wall thickness measured at our metallurgical laboratory. The two samples Flint H and G were severely impacted by corrosive water attack during their lifetime, as they both suffered from through the wall pipe pits. The remaining wall thickness was essentially zero in both pipe sections. Based on the condition of these pipes at the time we removed them, they were leaking at the time of removal, but the evaporate (dried minerals from the water after the water evaporated) had plugged the pits in both pipe fittings and temporarily halted the leaks.

Following the methodology of Edwards (2015) the damage done to the steel pipes during the Flint water crisis proceeded at up to 8.5 times the normally rate of corrosion in the DWSD water. Thus, during the 16-month period of exposure during the Flint Water Crisis, the pipes within Flint would have experienced corrosion damage of approximately 11.5 years or approximately an additional one quarter of the original pipe wall thickness would have been dissolved away during the Flint Water Crisis.

The steel pipe fittings were heavily tuberculated with iron oxide deposits. Under each tubercule is a pit that will penetrate the wall at some point in time (this had already occurred in samples labeled Flint G and H). The lead concentration in the scale on pipes G,H, I was 41.8, 168, 83.3 ppm, respectively, which are substantial lead concentrations that would be solubilized if the water became more corrosive (as it did during the Flint Water Crisis) and/or the corrosion inhibition program failed due to insufficient addition of chemicals.

Additionally, the overall average copper corrosion rate experienced by these pipes was substantially less than the corrosion rate experienced during the Flint Water Crisis. The minimal corrosion rate of the DWSD water was achieved in large part due to the efficacy of orthophosphate in controlling uniform copper corrosion. The impact of uniform corrosion is most readily observed due to the uniformity of presence of the greenish copper scale in the copper pipes on all quadrants of the pipe. No evidence of non-uniform corrosion (pitting) was observed in the sectioned pipes.

The copper pipe also shows the existence of a phosphate scale deposited by the water treatment chemicals added to the water. Thus, it is likely that a substantial amount of this wall thickness was dissolved due to corrosion during the Flint Water Crisis, because this pipe is currently well protected due to the effectiveness of the orthophosphate addition in reducing copper corrosion. When the addition of orthophosphate was terminated in 2014 simultaneously with the distribution of the substantially more corrosive and high chloride level treated Flint River water distributed throughout the Flint water system, it is clear that conditions were ripe for the rapid corrosion of the copper pipes.

This home was reported built in 1938, the water heater was last replaced after March 2019. The antecedent history of the original plumbing system is not documented.

Photo and analytical results of the section pipes removed from this home follow. The SEM/EDS spectra are included in the Attachments to this report, as are the "wet" chemistry analyses of the iron scale.

Figure 4.2-1: Pipe sample "E".

Figure 4.2-2: Pipe sample "E", sectioned

Figure 4.2-3: Pipe sample "F".

Figure 4.2-4: Pipe sample "F", sectioned.

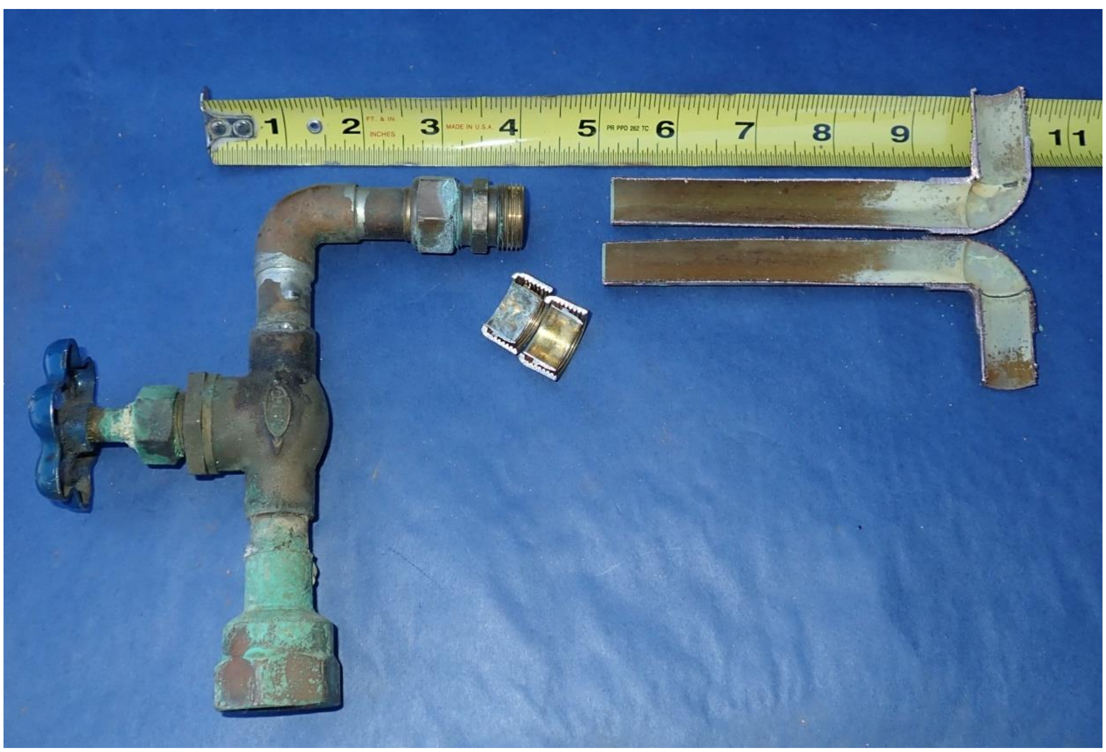


Figure 4.2-5: Pipe sample "F", sectioned, close up

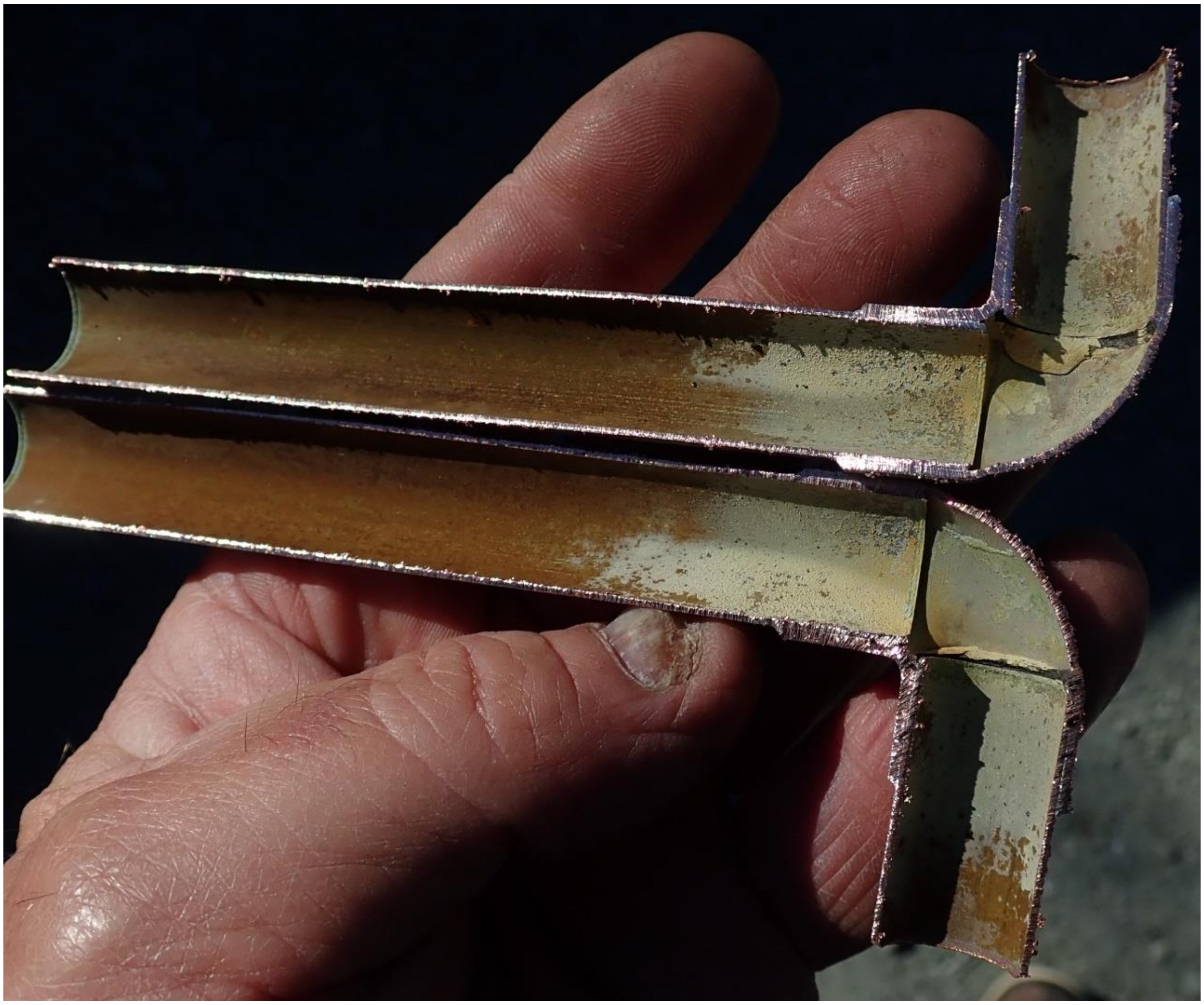


Figure 4.2-6: Pipe sample "G". Note the corrosion and scale present on the exterior of the tee indicative of a through wall leak.

Figure 4.2-7: Pipe sample "G", sectioned.

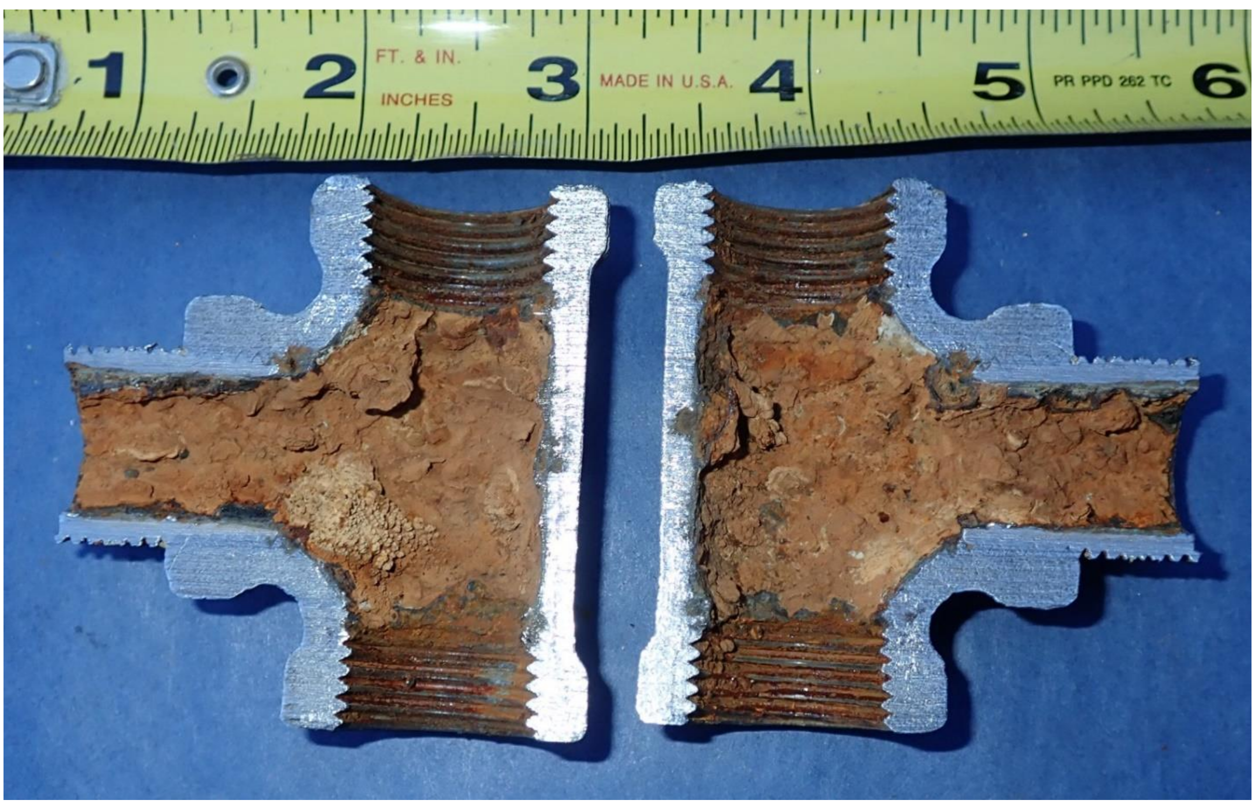


Figure 4.2-8: Pipe sample "H". Note the corrosion and scale present (white spot) on the exterior of the elbow indicative of a through wall leak.

Figure 4.2-9: Pipe sample "H", sectioned.

Figure 4.2-10: Pipe sample "I".

Figure 4.2-11: Pipe sample "I", sectioned.

5.3 Lab Work

The analysis was performed by scanning electron microscopy with energy dispersive spectroscopy (SEM-EDS). EDS provides semi-quantitative elemental analysis of materials in a scanning electron microscope based on characteristic energies of x-rays produced by the electron beam. EDS can normally detect elements with atomic number 4 (Beryllium) and above at concentrations as low as approximately 0.1 weight percent. As performed in this examination, EDS cannot detect the elements hydrogen, helium and lithium. As can be seen on the spectra reports in Attachments 1 and 2.

The water quality analysis methods are reported on the lab reports.

6 Discussion

As far as pipe sampling, essentially all readily obtainable steel pipe was removed from 1019 Montclair on February 9th 2022 and it is unlikely that any useful data can be collected by revisiting that location. Similarly, 119 Grace contains only copper pipe assembled in 2008 (reportedly) with low lead solder, and it is doubtful that additional pipe collection would do more than to disturb the occupants again.

The Tucker, Young, Jackson, Tull, Inc. (TYJT) report prepared in association with CH2M Hill, Inc. and Economic and Engineering Services Inc. prepared a comprehensive report in May of 1994 titled Lead and Copper Corrosion Control Optimization Study for the Detroit Water and Sewerage Department (DWSD). This report provided a path way to a logical successful approach for both of the City's water quality consultants. The failure to acknowledge the existence of this report and to adhere to the logic and data presented within the report, demonstrate that both LAN and Veolia practiced below the standard of care when they provided water quality engineering services for the City.

Essentially all of the homes in Flint (37,000) were built before 1985. Therefore, the Flint homes that are plumbed in copper contain high lead solder and are connected to high lead valves and faucets across Flint. Over 60 percent of Flint homes were built before 1945 when lead service laterals were still in common use. There are substantial amounts of piping and faucets that exceed the lead levels that are currently allowed in essentially all of the Flint homes. The only solution is to remove or bypass these high-lead containing piping materials, which will restore the life of the Flint home and business plumbing systems by repairing the damage done during the Flint Water Crisis by the corrosive treated Flint River water.

By focusing on just two homes of the named plaintiffs, located at 119 Grace St and 1019 Montclair, the defendants artificially narrowed the useful data collected during their field work. To be consistent with the defense focus, I chose to remove pipe sections from those same houses to avoid adding even more variables into the data being collected. Reviewing the pipes from two homes provides infinitely more information/data than was collected during the defense review of these homes, as the interior of the pipes can be observed, analytically measured, and the wall thickness measured.

The Detroit Water and Sewage Department's orthophosphate addition corrosion treatment regime was (and is) very effective at minimizing corrosion of copper pipes in the Detroit water distribution system which includes Flint. The effective corrosion rate of the DWSD water in the copper pipes observed from 119 Grace was substantially less than the 0.0005 inches (0.5 mils) per year utilized by the Copper Development Association (CDA) in their 50-year warranty for copper pipe.

The copper pipes at 119 Grace were reportedly installed in 2008 during a plumbing remodel and, as such, they were assembled without leaded solder. These pipes were however, were still impacted by the corrosive water distributed during the Flint Water Crisis, losing approximately 0.002 inches of their wall thickness. The steel pipes at 1019 Montclair were impacted severely during the exposure to the corrosive water during the Flint Water Crisis. These pipes experienced through wall pitting and were down to paper thin remaining wall thickness in many locations at the time that I removed them.

Exposure to the corrosive water distributed during the Flint Water Crisis substantially compromised the life span of the steel pipes in Flint. Just as the steel pipe service laterals were removed by the City and replaced with copper, the steel pipes within these houses require replacement to halt exposure to the lead containing scale accumulated over many years from their lead service laterals. The Flint Water Crisis made these lead scales more readily exposed due the aggressive Flint River water attack on these scales. Replacement will provide the residents with a plumbing life span required to service these homes in the future without catastrophic leakage and failure.

Based on the work of Dr. Marc Edwards in 2015, the steel pipes in Flint were rapidly aged by the distributed Flint River water. Dr. Edwards demonstrated that the treated Flint River water was 8.5 times more corrosive than the DWSD water. The corrosive nature of this water resulted in the pipes experiencing over 11 years of additional corrosion damage in the 16 months of the Flint Water Crisis. The resulting wall thinning damage during the Flint Water Crisis is a direct analogy to the "straw that broke the camel's back" rendering the need to require full pipe replacement at the homes and businesses in Flint.

If LAN and/or Veolia had insisted on the addition of orthophosphate, while they were retained by the City of Flint, the impact of corrosive water during the Flint Water Crisis could have been minimized. Minimizing these impacts would have reduced the accelerated corrosion from the treated Flint River water that impacted residential and business plumbing systems.

The copper pipes at 1019 Montclair were impacted by the corrosive water served during the Flint Water Crisis losing approximately 0.006 inches of the wall thickness. This reduction in thickness most likely occurred during that Flint Water Crisis when orthophosphate was not added.

The lead levels remaining in the heavily corroded and tuberculated steel pipe sections collected from 1019 Montclair (and most likely at all other similarly plumbed homes having water service laterals made from lead) are excessive and present a risk that can only be addressed by complete re-plumbing due. The requirement for a replumb results from the severity of the corrosion damage, pitting of these pipes, the quantity of lead containing scale, and the high levels of lead remaining in the pipe scale. Consistent

their age, and as was confirmed by the defense data collection with an XRF, the brass faucets and valves in these homes have high lead content. This high lead content exceeds the current standards for lead content by up to two orders of magnitude and likewise will require removal and updating with fixtures that meet the current lead content standard of less than 0.25 percent lead requirement. The condition of the residual scale that remains in the pipes today with the high lead content scale is a problem that needs to be corrected immediately.

Attachments

1. Laboratory Testing Results: 119 Grace Street
2. Laboratory Testing Results: 1910 Montclair
3. Laboratory Reports on the interior scale

References

1. *DWSD Lead and Copper Corrosion Control Optimization Study (1994): Executive Summary. Volumes One and Two. TYJT, CH2M Hill Inc. and Economic and Engineering Services, Inc.*
2. http://flintwaterstudy.org/2015/09/research-update-corrosivity-of-flint-water-to-iron-pipes-in-the-city-a-costly-problem/
3. Marvin Gnagy deposition dated December 12, 2019
4. P. Goovaerts. *Science of the Total Environment* 599-600 (2017) 1552-1563

Attachment 1:

Laboratory Testing Results:

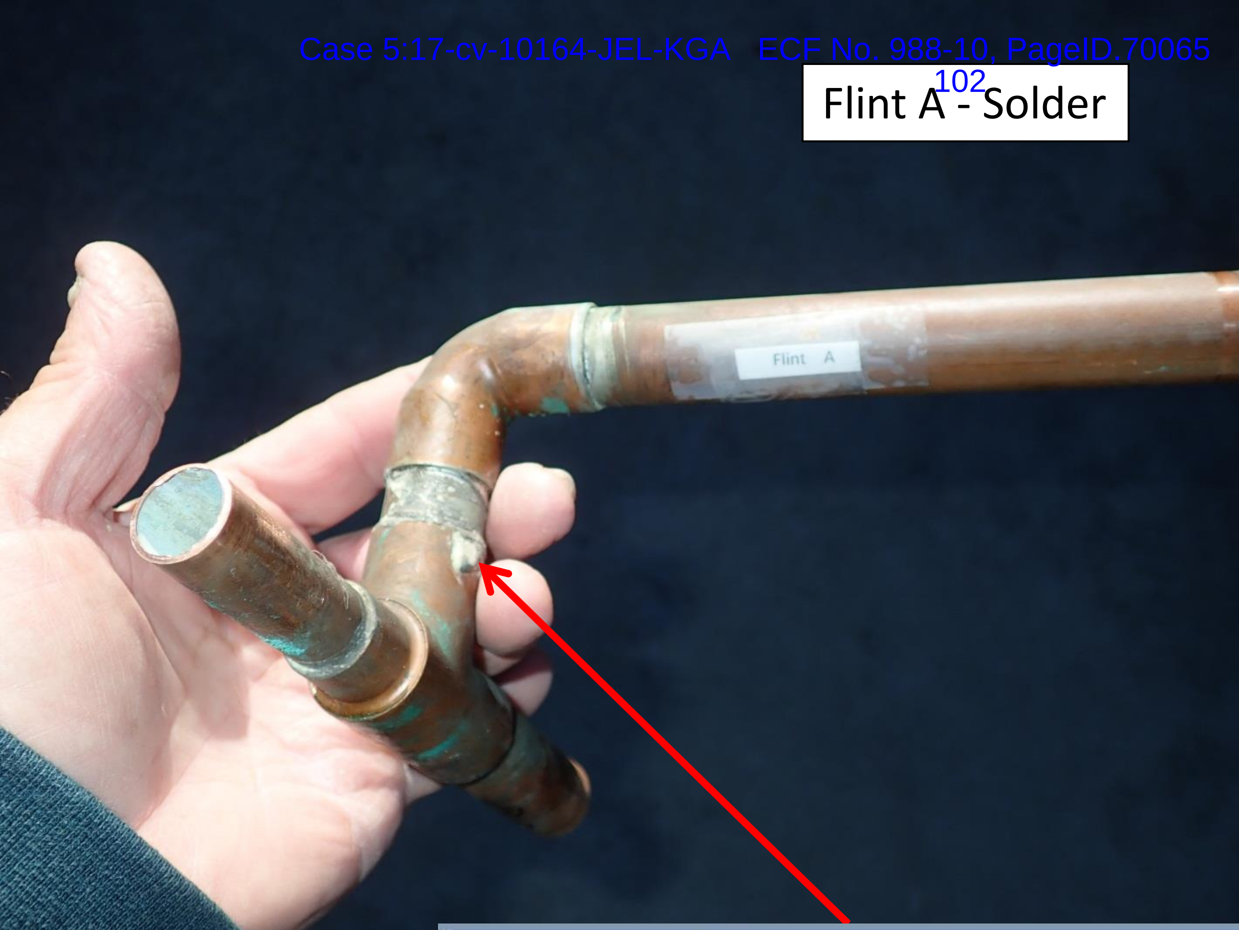
119 Grace Street

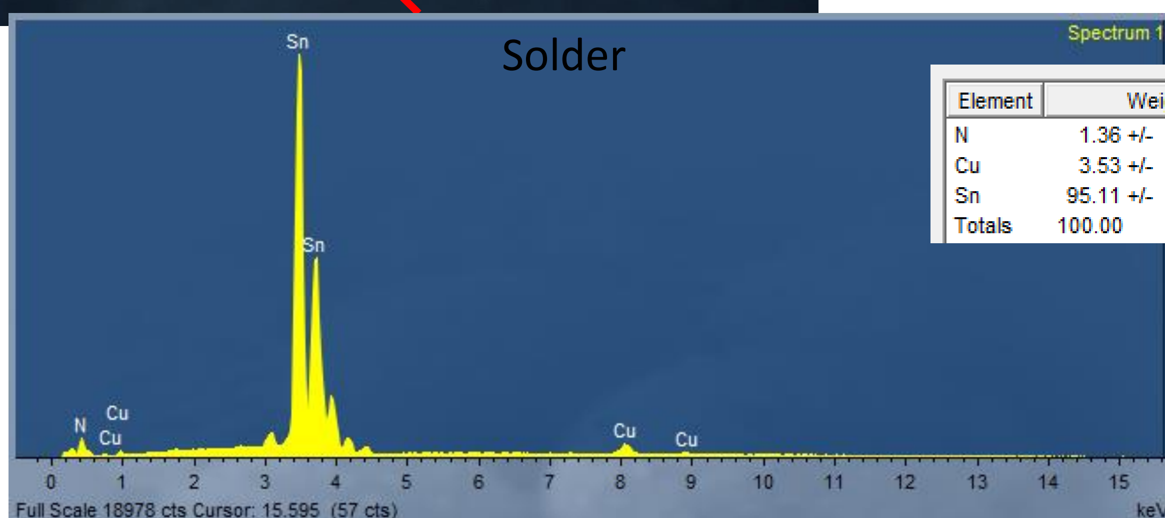
Project No: 22004
Date: Feb. 21, 2022
Client: REED
Project Name /Description: 119 Grace, Flint

Notes & Remarks:

The analysis was performed by scanning electron microscopy with energy dispersive spectroscopy (SEM-EDS). EDS provides semi-quantitative elemental analysis of materials in a scanning electron microscope based on characteristic energies of x-rays produced by the electron beam. EDS can normally detect elements with atomic number 4 (Beryllium) and above at concentrations as low as approximately 0.1 weight percent. As performed in this examination, EDS cannot detect the elements hydrogen, helium and lithium.

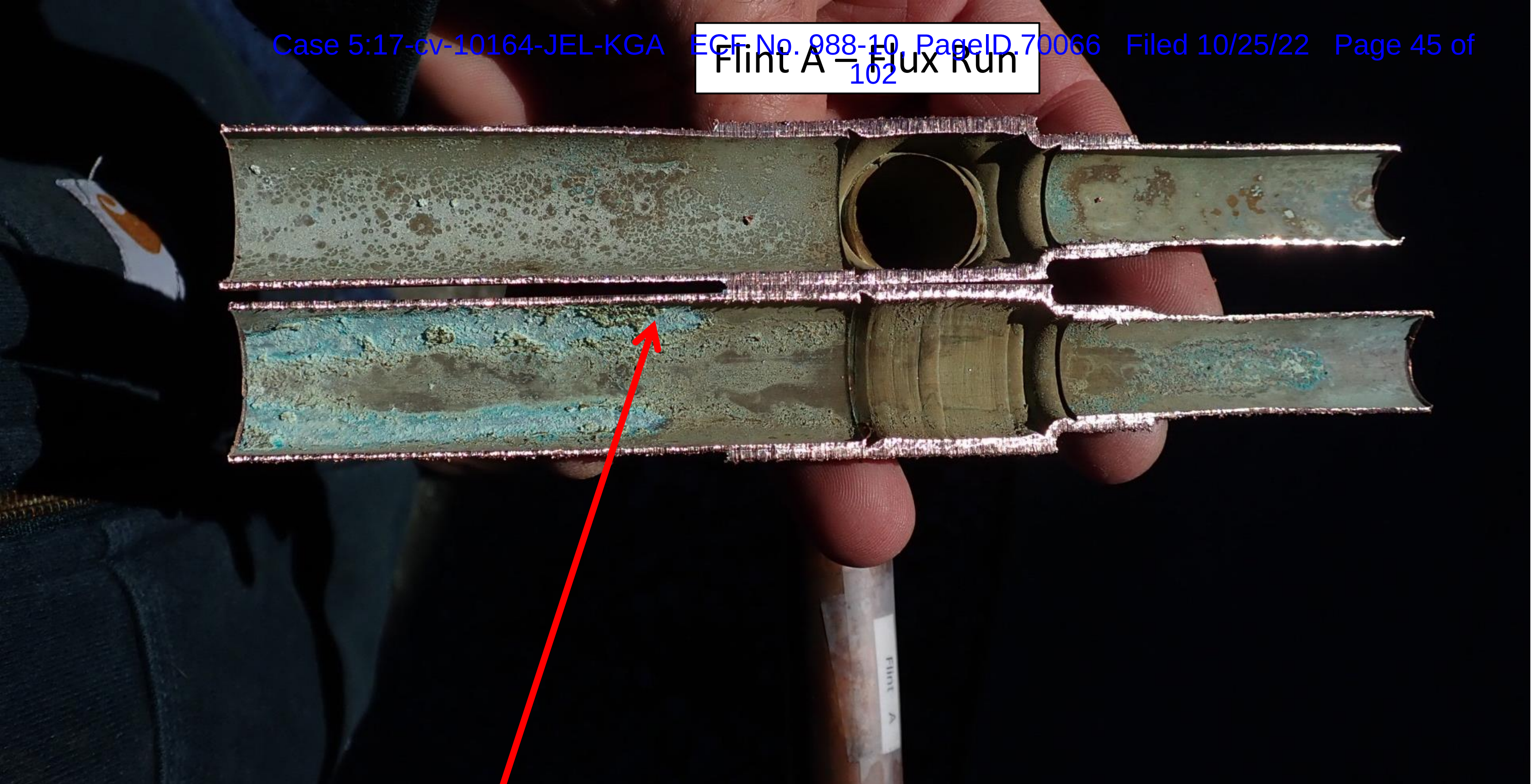
Flint A - Solder

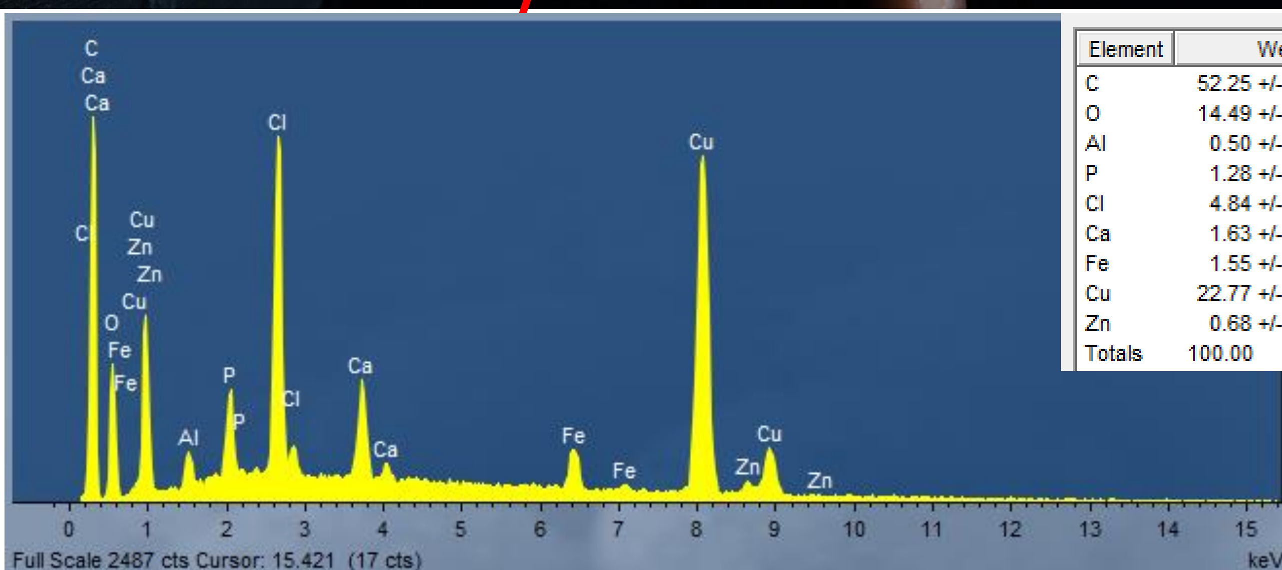




Element	Weight%
N	1.36 +/- 0.68
Cu	3.53 +/- 0.16
Sn	95.11 +/- 0.67
Totals	100.00

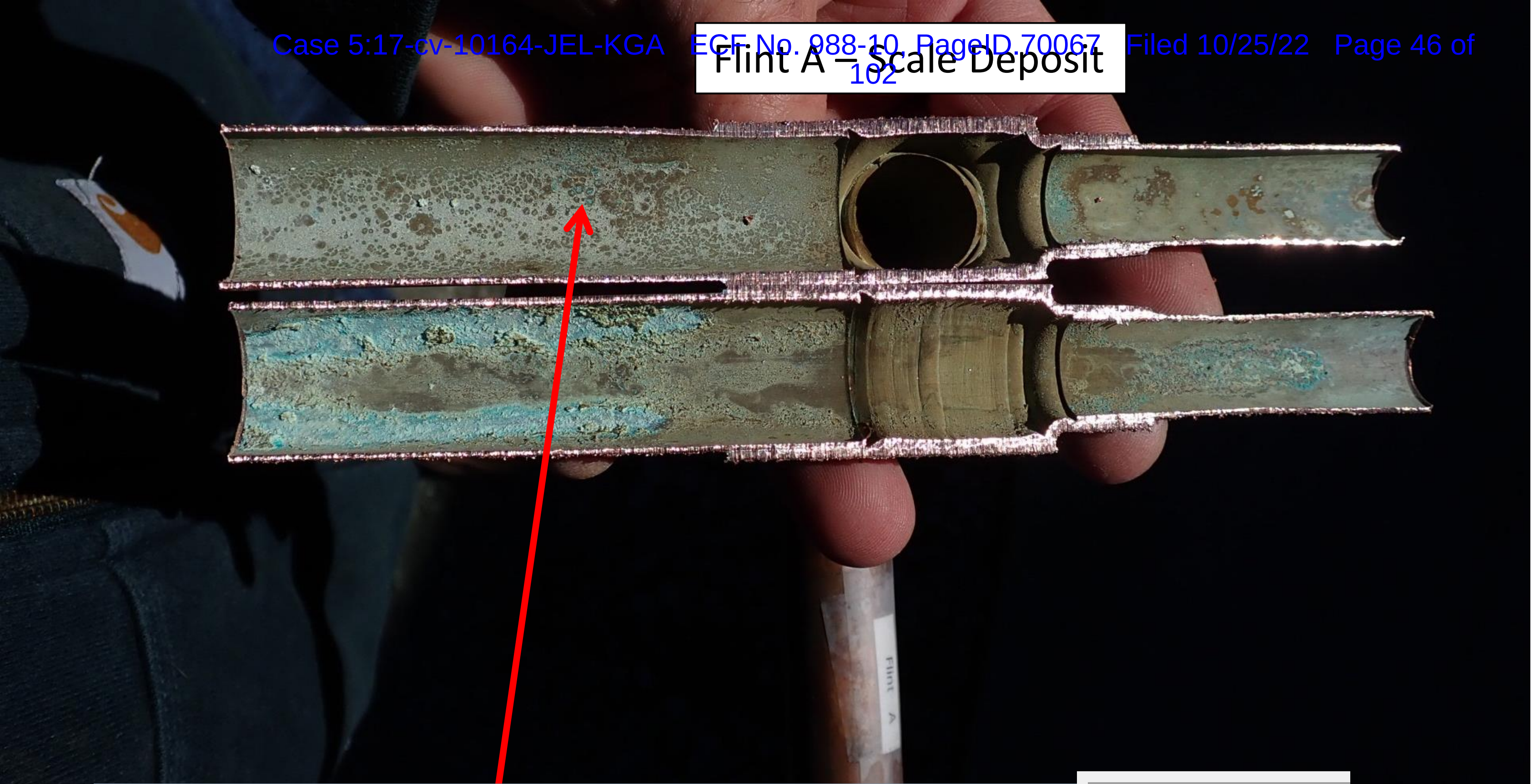
Flint A – Flux Run

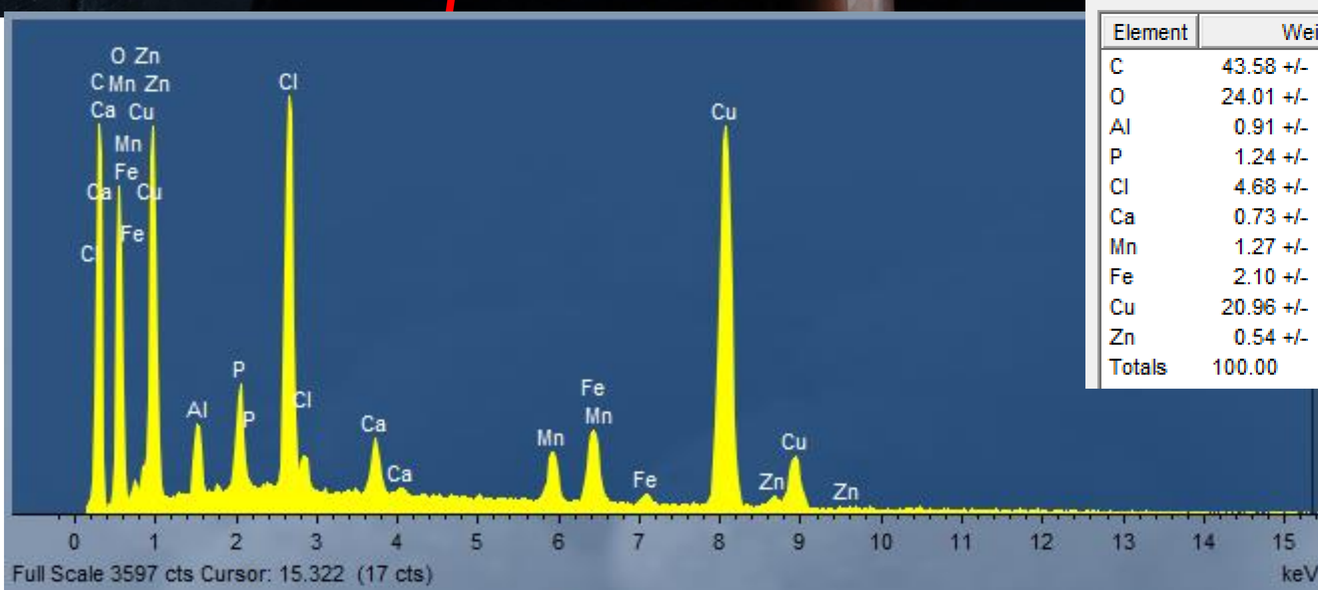




Element	Weight%
C	52.25 +/- 0.64
O	14.49 +/- 0.48
Al	0.50 +/- 0.05
P	1.28 +/- 0.07
Cl	4.84 +/- 0.11
Ca	1.63 +/- 0.07
Fe	1.55 +/- 0.08
Cu	22.77 +/- 0.37
Zn	0.68 +/- 0.14
Totals	100.00

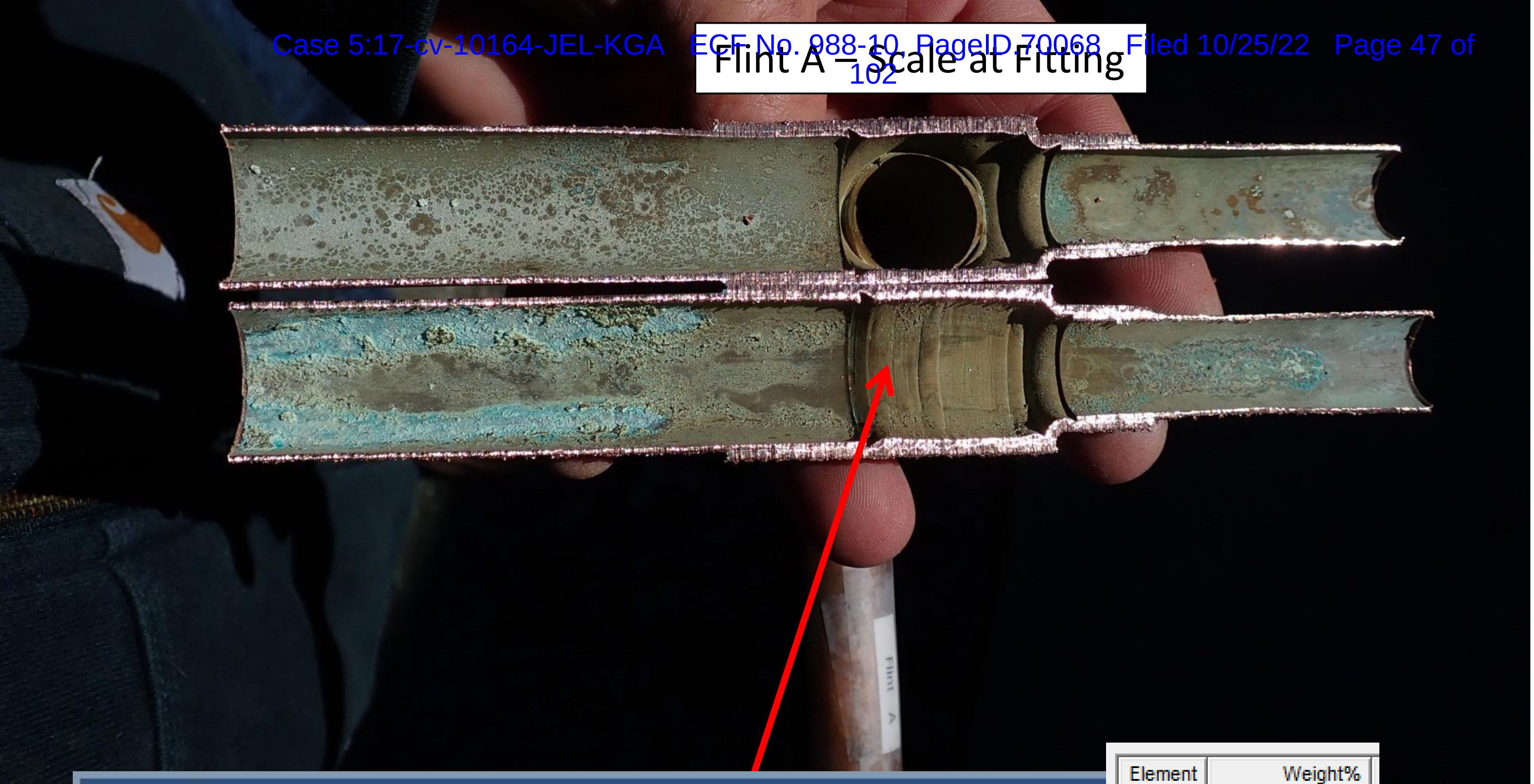
Flint A – Scale Deposit

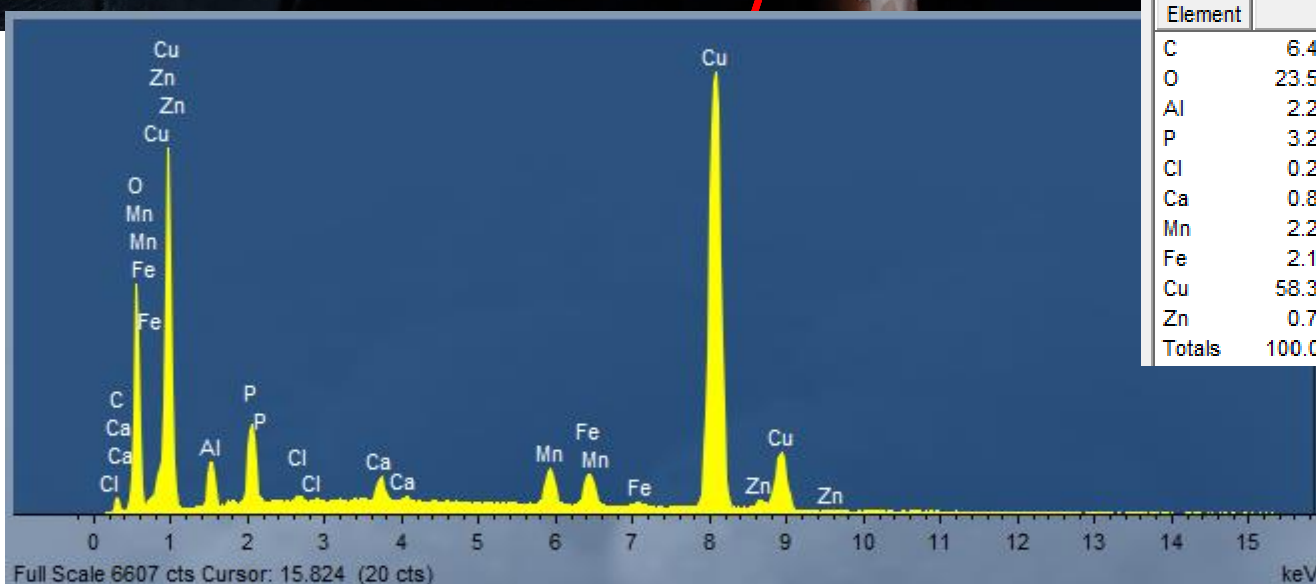




Element	Weight%
C	43.58 +/- 0.52
O	24.01 +/- 0.42
Al	0.91 +/- 0.05
P	1.24 +/- 0.05
Cl	4.68 +/- 0.08
Ca	0.73 +/- 0.04
Mn	1.27 +/- 0.06
Fe	2.10 +/- 0.07
Cu	20.96 +/- 0.27
Zn	0.54 +/- 0.09
Totals	100.00

Flint A – Scale at Fitting

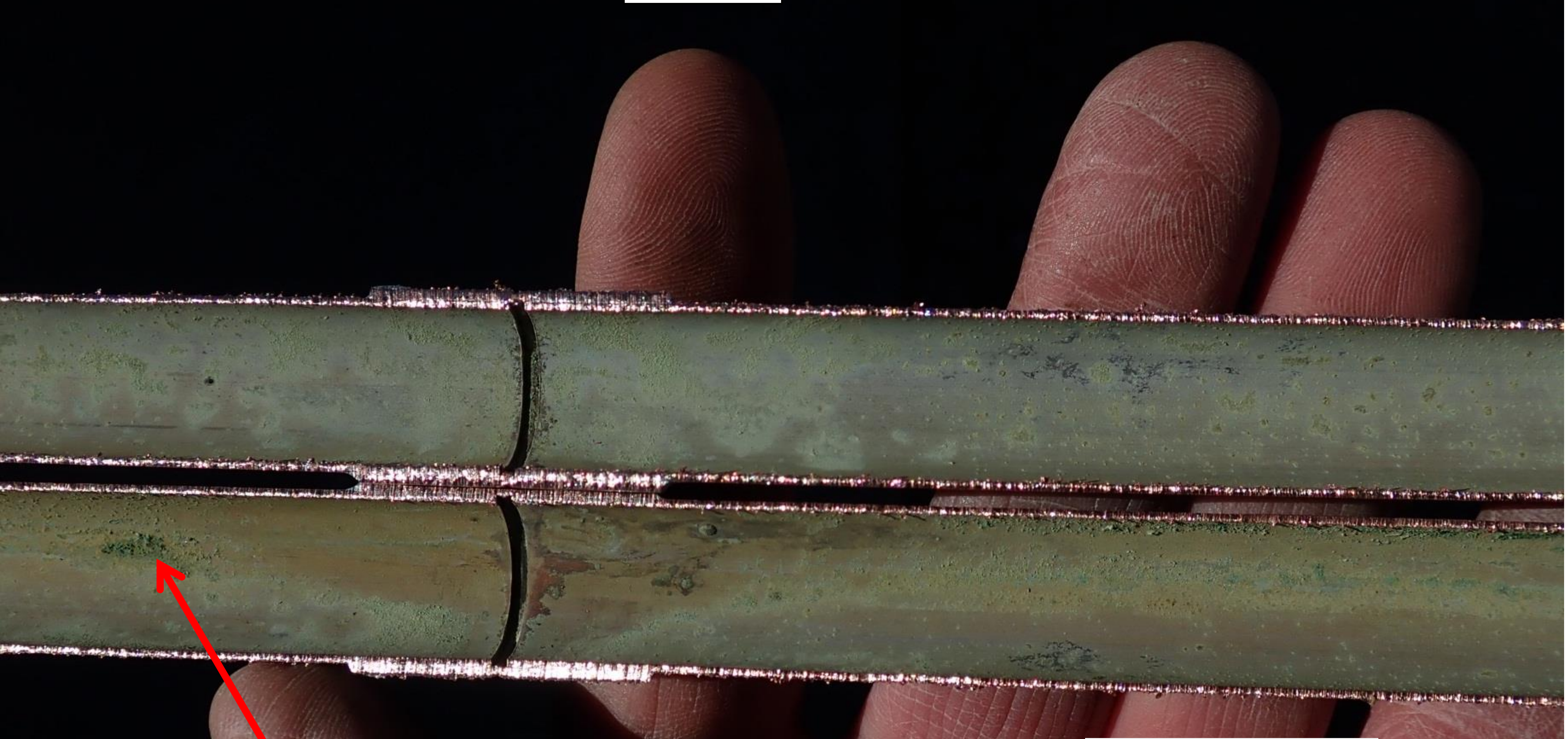


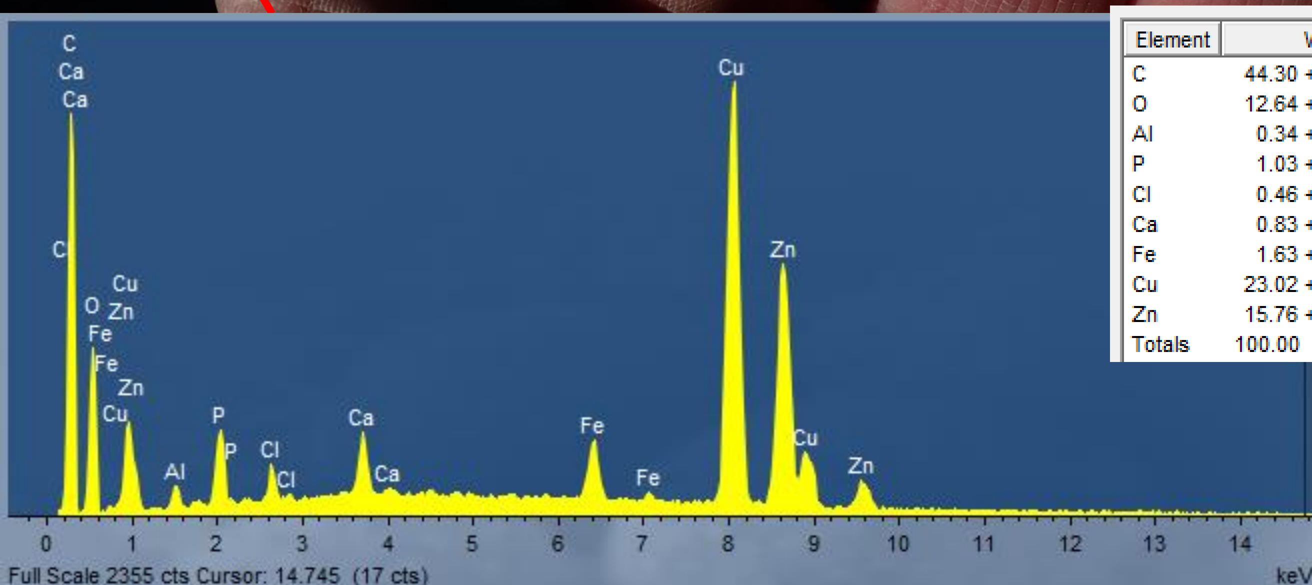


Element	Weight%
C	6.44 +/- 0.53
O	23.53 +/- 0.36
Al	2.20 +/- 0.09
P	3.29 +/- 0.10
Cl	0.25 +/- 0.05
Ca	0.83 +/- 0.05
Mn	2.20 +/- 0.09
Fe	2.10 +/- 0.09
Cu	58.38 +/- 0.46
Zn	0.77 +/- 0.15
Totals	100.00

Flint B

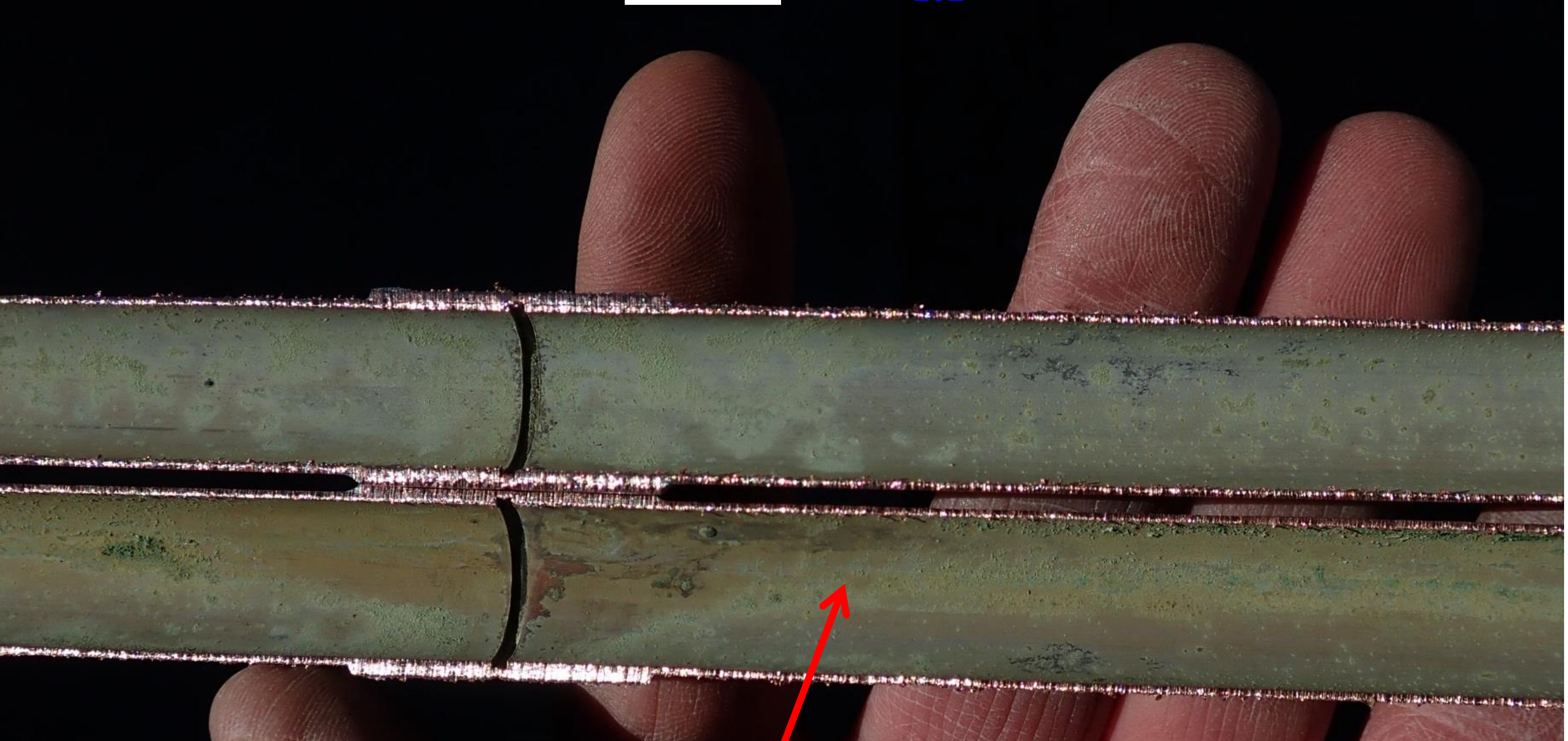
Flint B

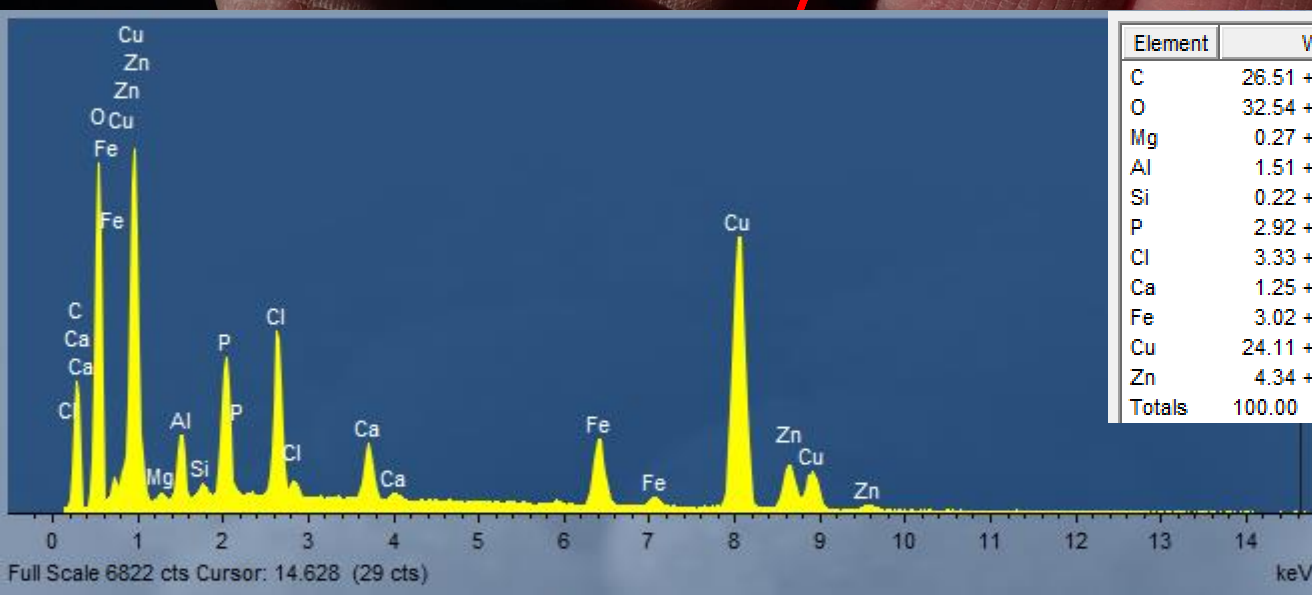




Element	Weight%
C	44.30 +/- 0.59
O	12.64 +/- 0.38
Al	0.34 +/- 0.04
P	1.03 +/- 0.06
Cl	0.46 +/- 0.04
Ca	0.83 +/- 0.05
Fe	1.63 +/- 0.08
Cu	23.02 +/- 0.34
Zn	15.76 +/- 0.30
Totals	100.00

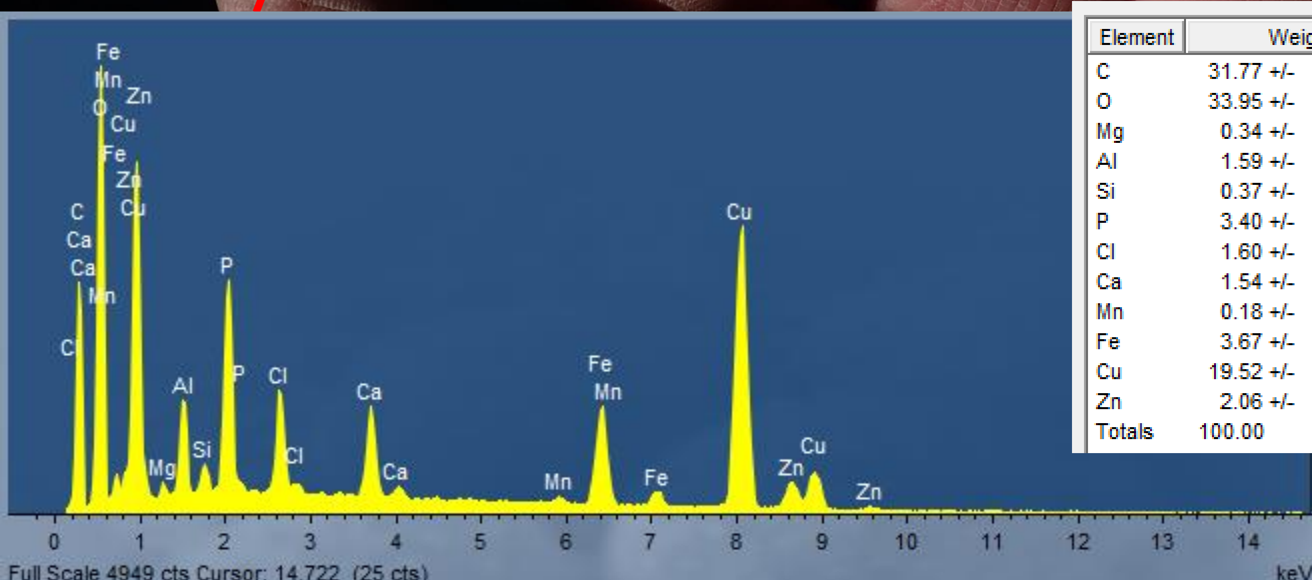
Flint B





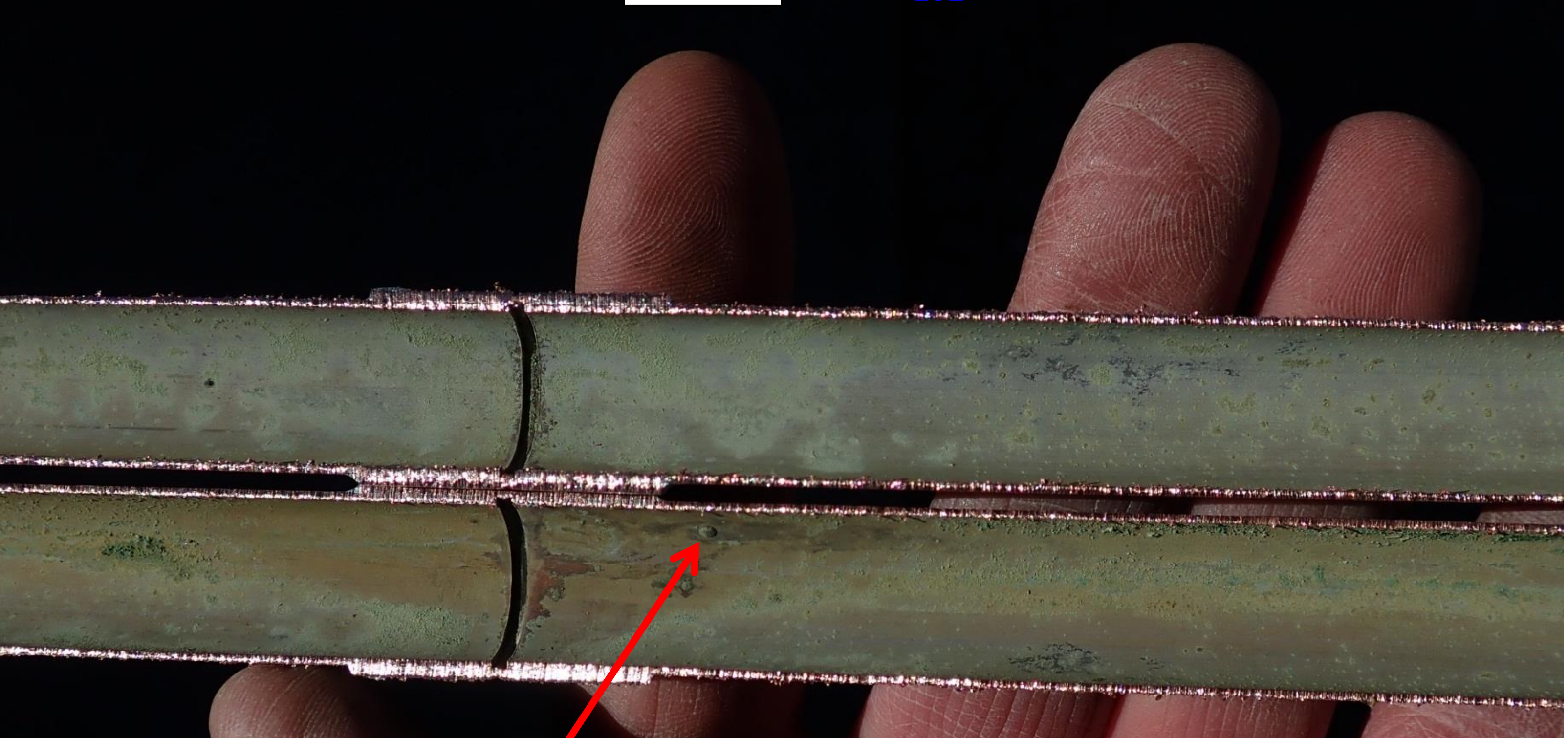
Element	Weight%
C	26.51 +/- 0.52
O	32.54 +/- 0.38
Mg	0.27 +/- 0.05
Al	1.51 +/- 0.05
Si	0.22 +/- 0.04
P	2.92 +/- 0.07
Cl	3.33 +/- 0.06
Ca	1.25 +/- 0.04
Fe	3.02 +/- 0.07
Cu	24.11 +/- 0.26
Zn	4.34 +/- 0.14
Totals	100.00

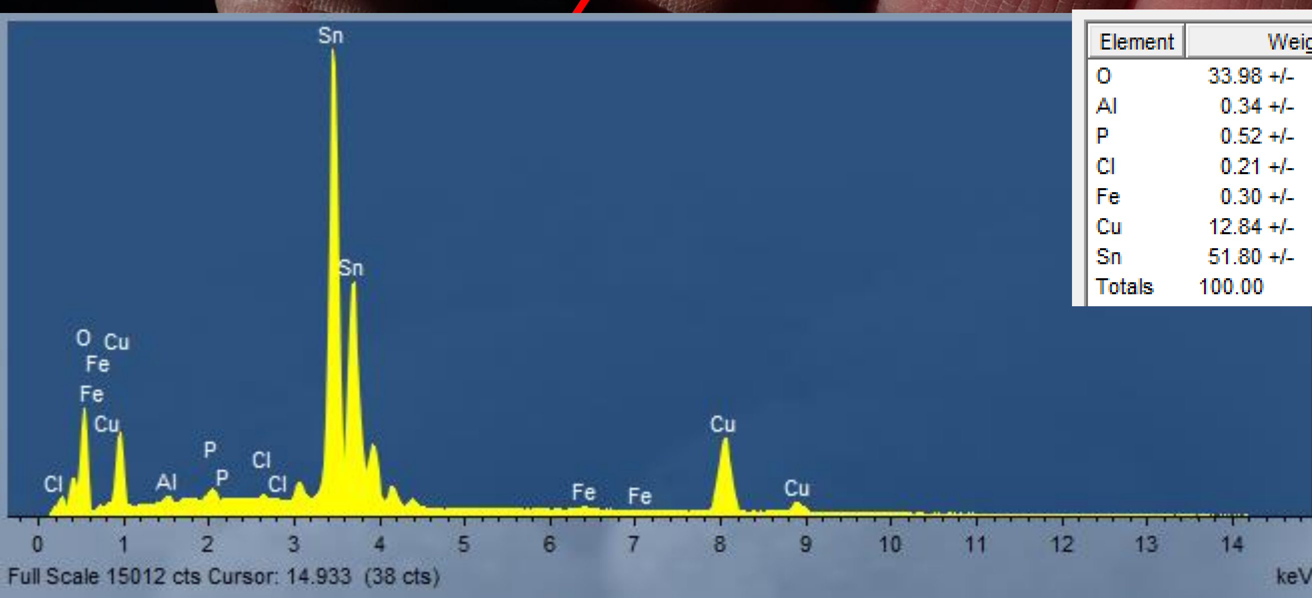
Flint B



Element	Weight%
C	31.77 +/- 0.50
O	33.95 +/- 0.41
Mg	0.34 +/- 0.05
Al	1.59 +/- 0.06
Si	0.37 +/- 0.04
P	3.40 +/- 0.07
Cl	1.60 +/- 0.05
Ca	1.54 +/- 0.05
Mn	0.18 +/- 0.04
Fe	3.67 +/- 0.08
Cu	19.52 +/- 0.24
Zn	2.06 +/- 0.11
Totals	100.00

Flint B





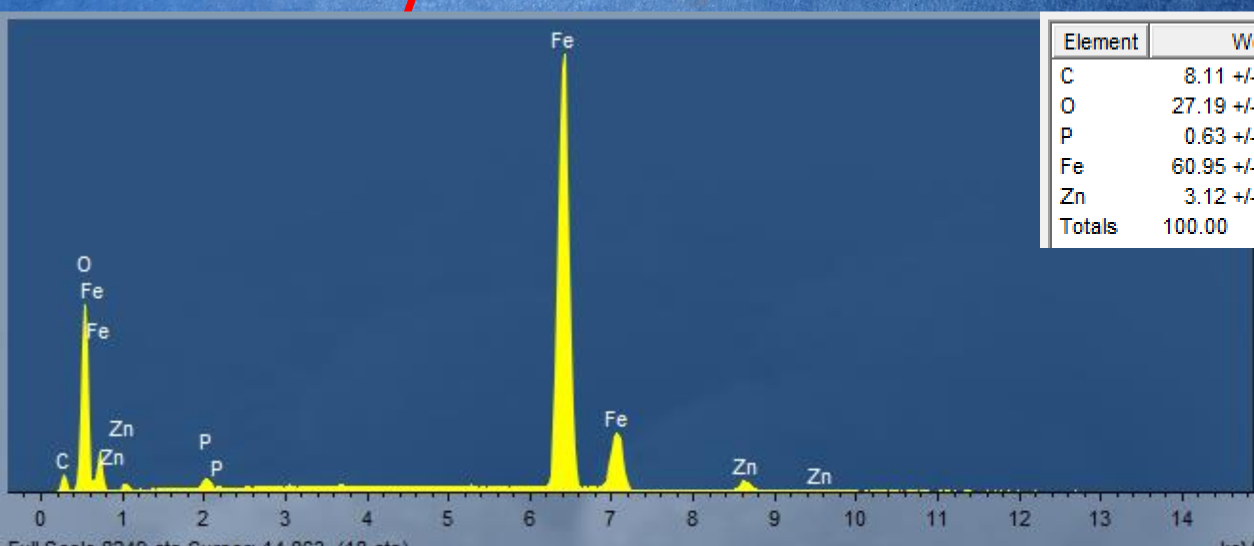
Element	Weight%
O	33.98 +/- 0.46
Al	0.34 +/- 0.05
P	0.52 +/- 0.05
Cl	0.21 +/- 0.04
Fe	0.30 +/- 0.06
Cu	12.84 +/- 0.17
Sn	51.80 +/- 0.38
Totals	100.00

Flint C


FT. & IN.
INCHES
MADE IN U.S.A.
PR PPD 262 TC
Flint C

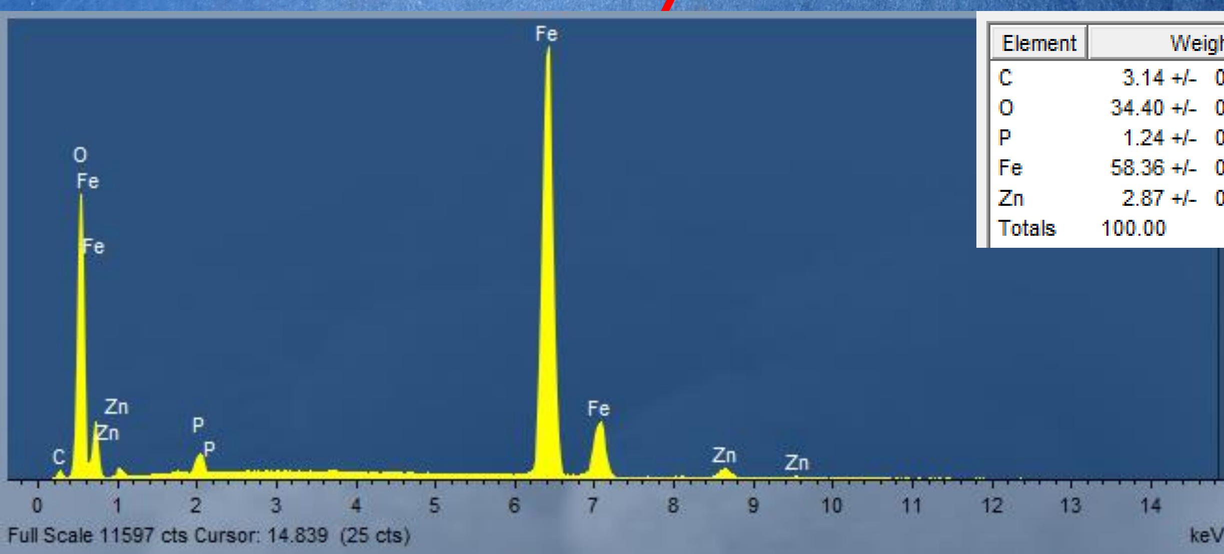

FT. & IN.
INCHES
MADE IN U.S.A.
PR PPD 262 TC

Flint C



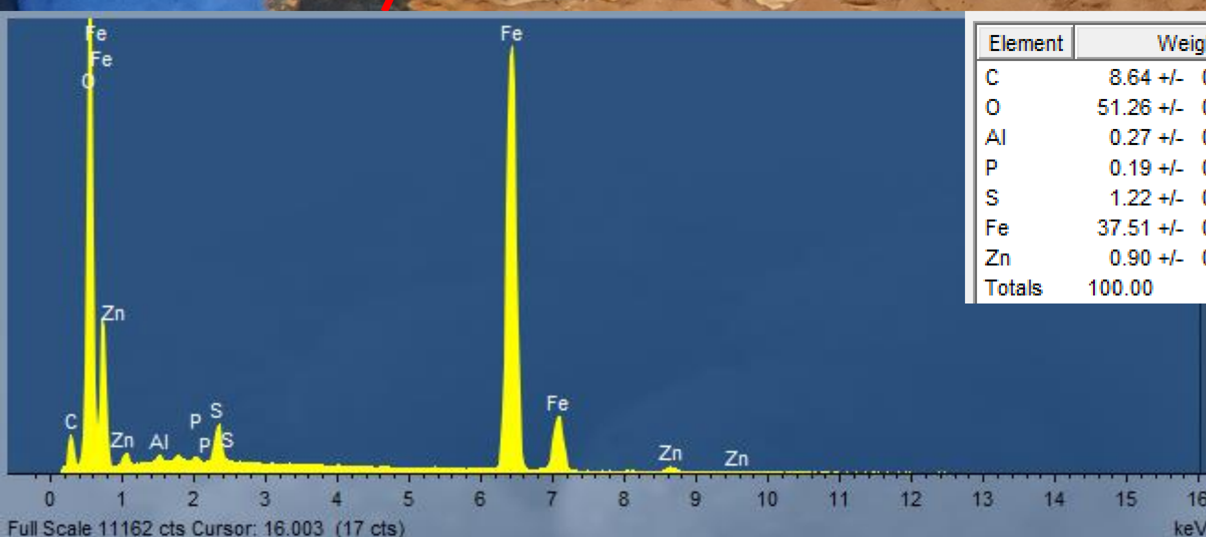
Element	Weight%
C	8.11 +/- 0.47
O	27.19 +/- 0.36
P	0.63 +/- 0.06
Fe	60.95 +/- 0.45
Zn	3.12 +/- 0.17
Totals	100.00

Flint C



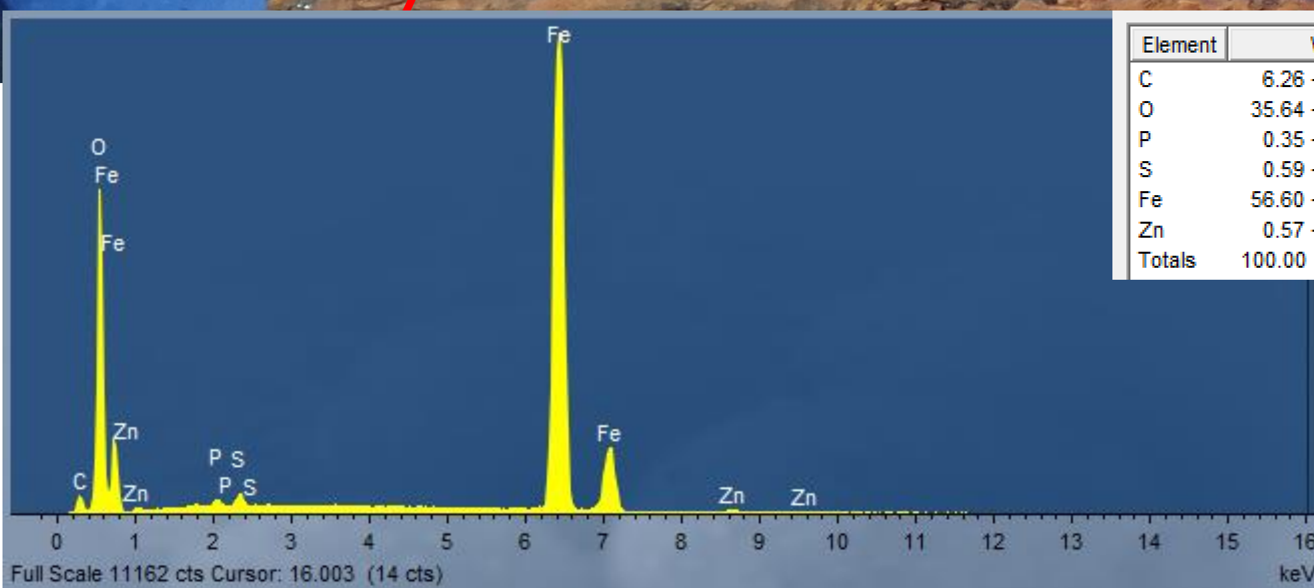
Element	Weight%
C	3.14 +/- 0.35
O	34.40 +/- 0.30
P	1.24 +/- 0.07
Fe	58.36 +/- 0.34
Zn	2.87 +/- 0.14
Totals	100.00

Flint C



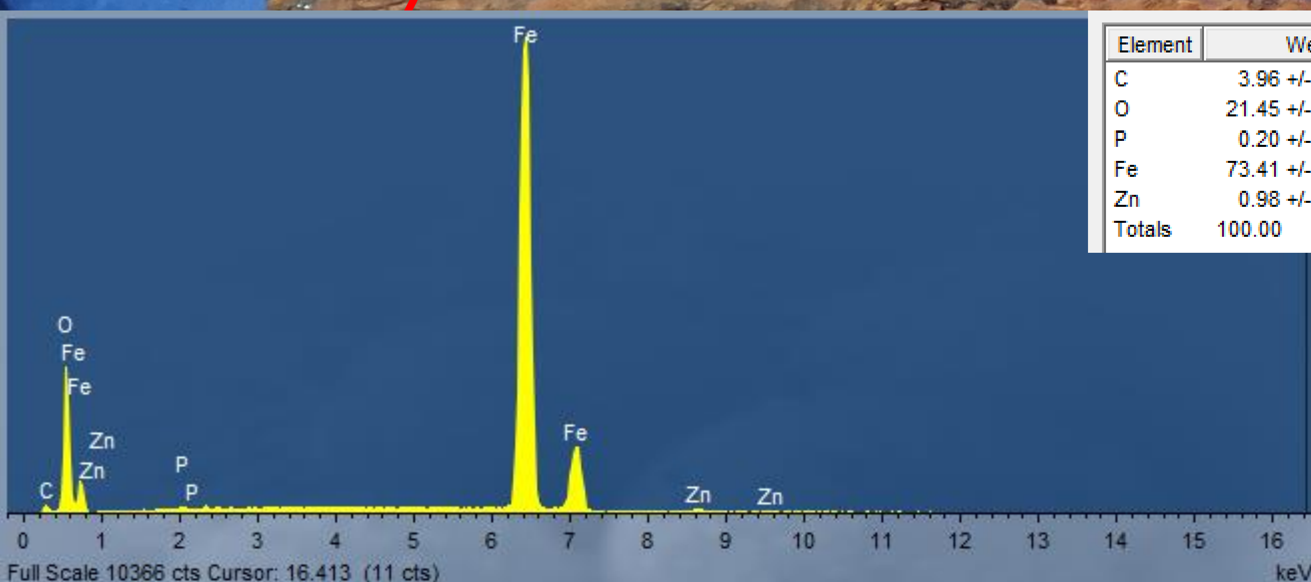
Element	Weight%
C	8.64 +/- 0.35
O	51.26 +/- 0.29
Al	0.27 +/- 0.04
P	0.19 +/- 0.04
S	1.22 +/- 0.04
Fe	37.51 +/- 0.24
Zn	0.90 +/- 0.08
Totals	100.00

Flint C

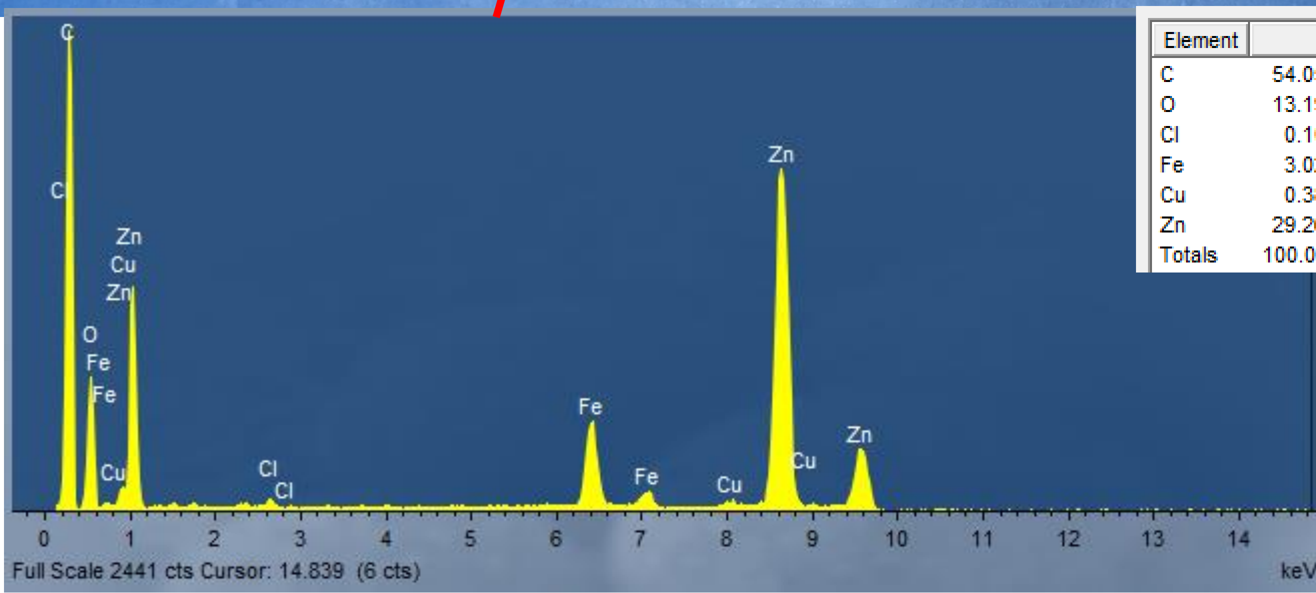


Element	Weight%
C	6.26 +/- 0.38
O	35.64 +/- 0.31
P	0.35 +/- 0.05
S	0.59 +/- 0.05
Fe	56.60 +/- 0.35
Zn	0.57 +/- 0.10
Totals	100.00

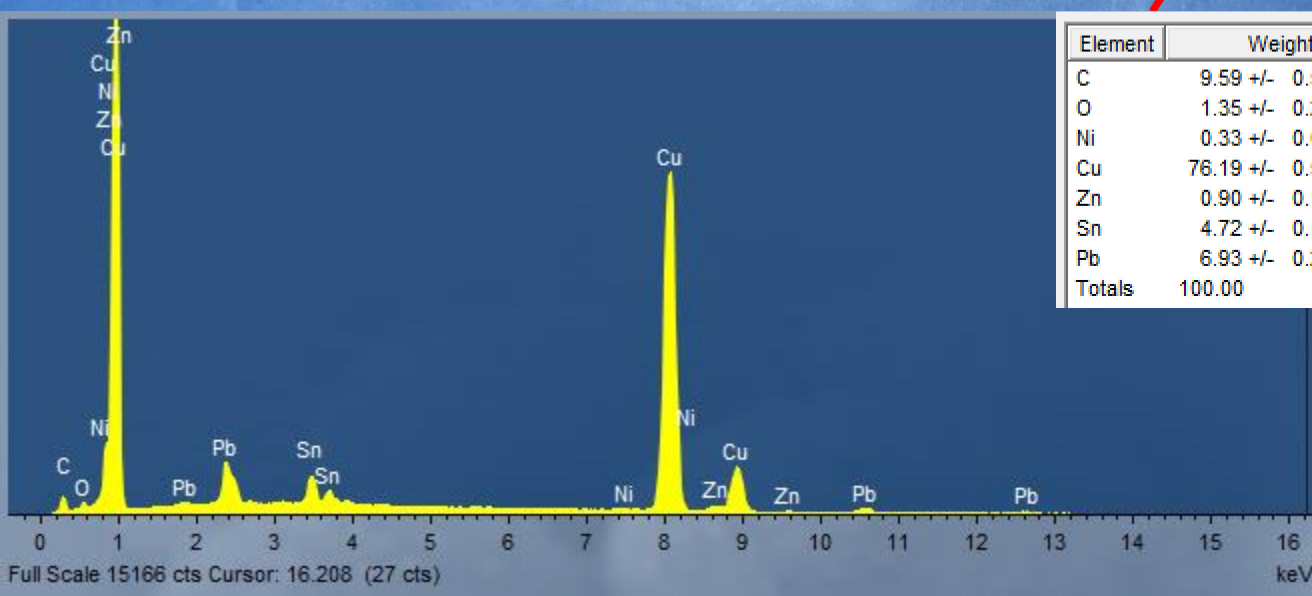
Flint C



Element	Weight%
C	3.96 +/- 0.39
O	21.45 +/- 0.31
P	0.20 +/- 0.05
Fe	73.41 +/- 0.42
Zn	0.98 +/- 0.14
Totals	100.00



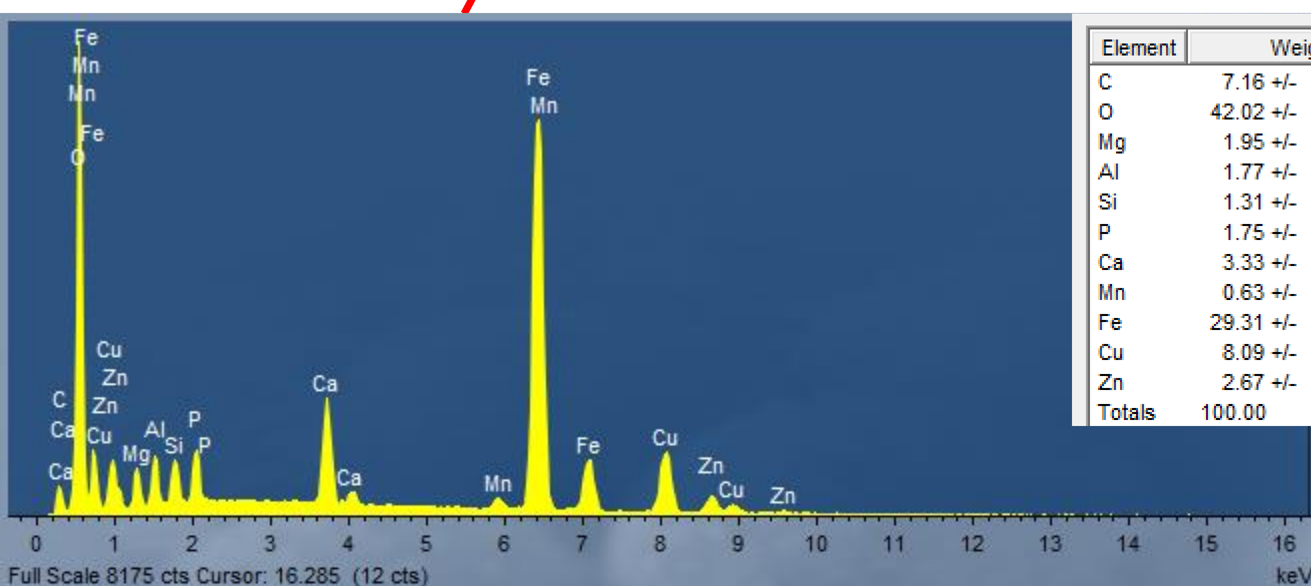
Element	Weight%
C	54.05 +/- 0.58
O	13.19 +/- 0.44
Cl	0.10 +/- 0.02
Fe	3.02 +/- 0.10
Cu	0.38 +/- 0.08
Zn	29.26 +/- 0.43
Totals	100.00



Element	Weight%
C	9.59 +/- 0.53
O	1.35 +/- 0.21
Ni	0.33 +/- 0.08
Cu	76.19 +/- 0.55
Zn	0.90 +/- 0.14
Sn	4.72 +/- 0.15
Pb	6.93 +/- 0.26
Totals	100.00

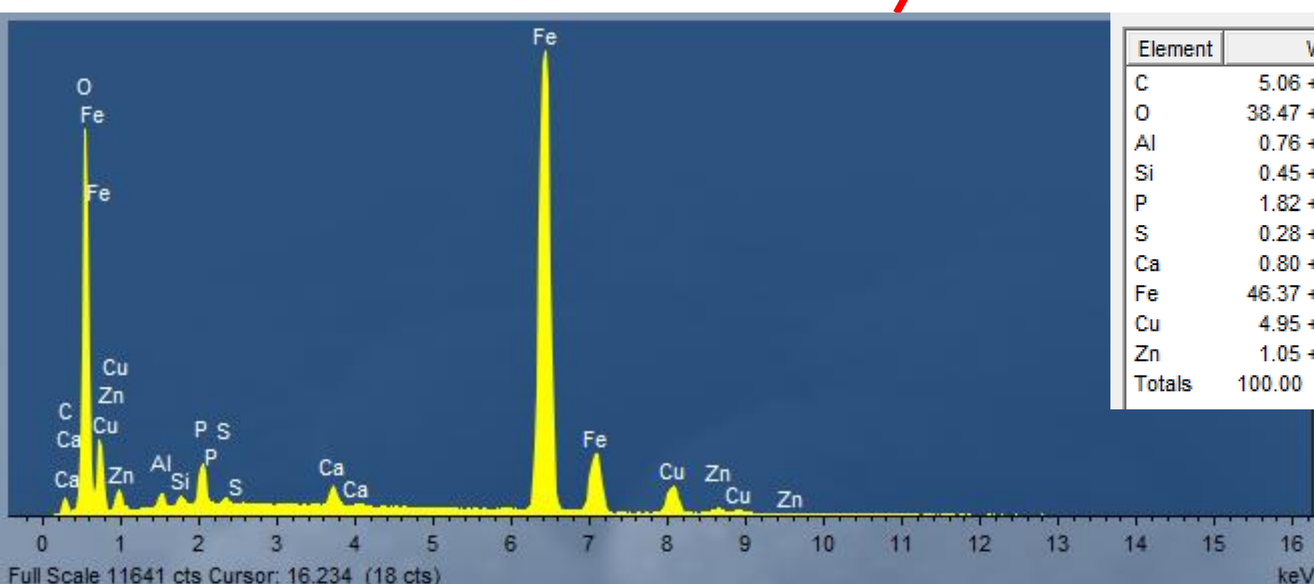
Flint D

Flint D

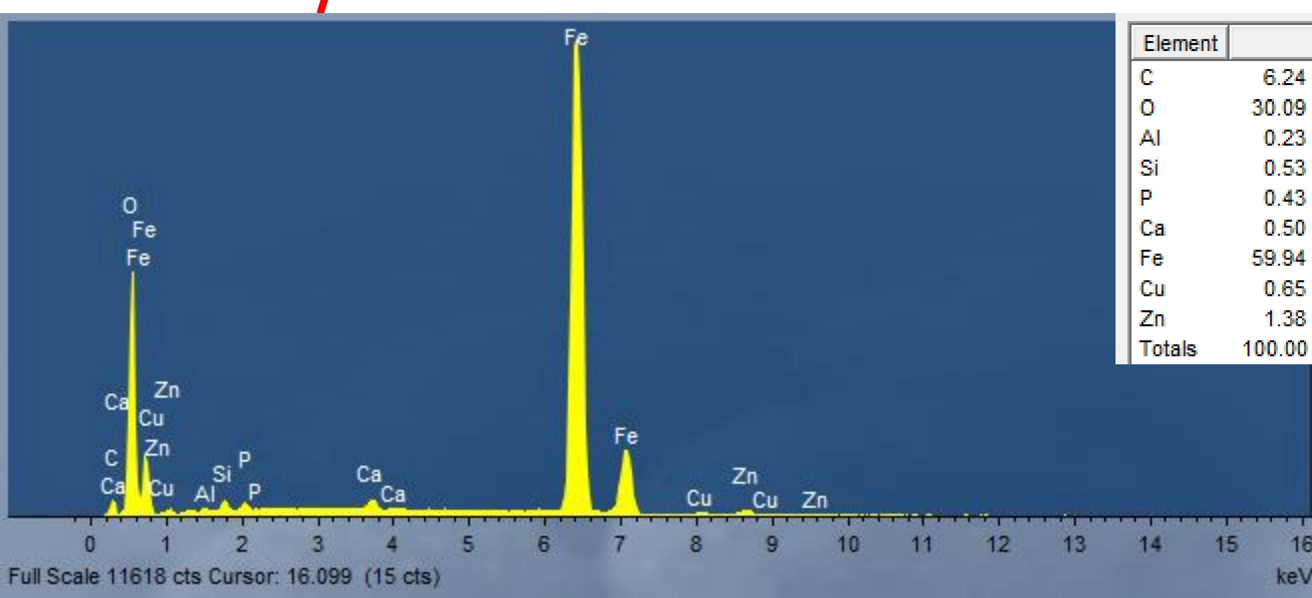


Element	Weight%
C	7.16 +/- 0.38
O	42.02 +/- 0.34
Mg	1.95 +/- 0.08
Al	1.77 +/- 0.07
Si	1.31 +/- 0.06
P	1.75 +/- 0.07
Ca	3.33 +/- 0.06
Mn	0.63 +/- 0.06
Fe	29.31 +/- 0.24
Cu	8.09 +/- 0.16
Zn	2.67 +/- 0.13
Totals	100.00

Flint D

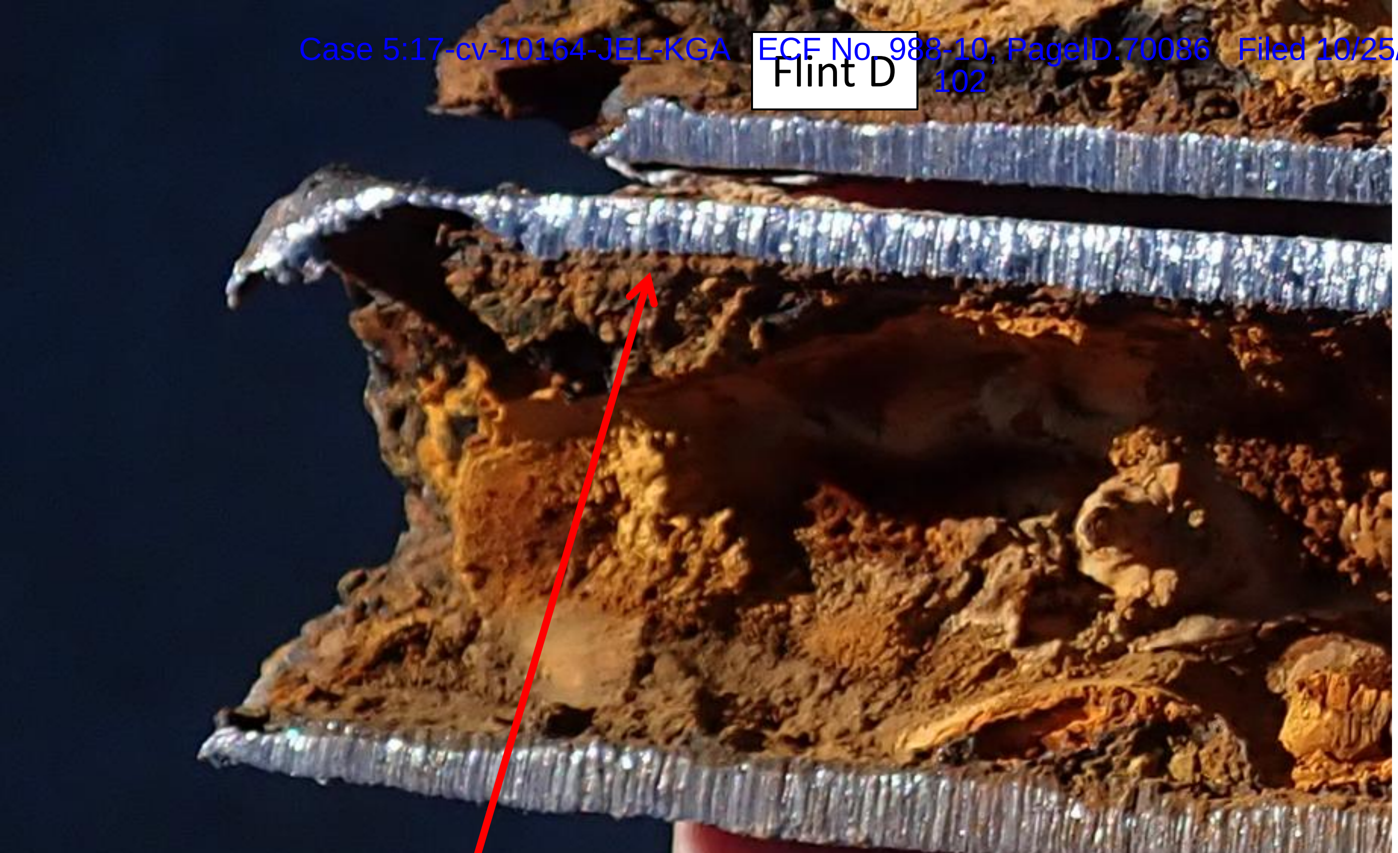


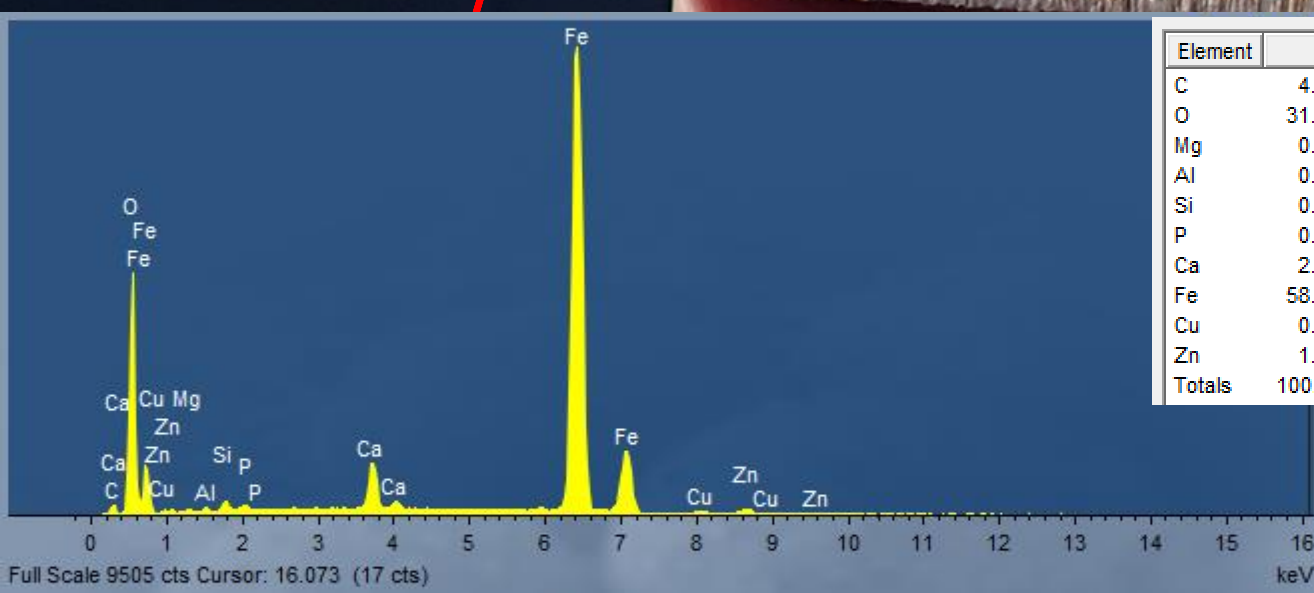
Element	Weight%
C	5.06 +/- 0.35
O	38.47 +/- 0.29
Al	0.76 +/- 0.06
Si	0.45 +/- 0.05
P	1.82 +/- 0.07
S	0.28 +/- 0.04
Ca	0.80 +/- 0.04
Fe	46.37 +/- 0.29
Cu	4.95 +/- 0.13
Zn	1.05 +/- 0.11
Totals	100.00



Element	Weight%
C	6.24 +/- 0.38
O	30.09 +/- 0.31
Al	0.23 +/- 0.05
Si	0.53 +/- 0.05
P	0.43 +/- 0.05
Ca	0.50 +/- 0.04
Fe	59.94 +/- 0.37
Cu	0.65 +/- 0.09
Zn	1.38 +/- 0.12
Totals	100.00

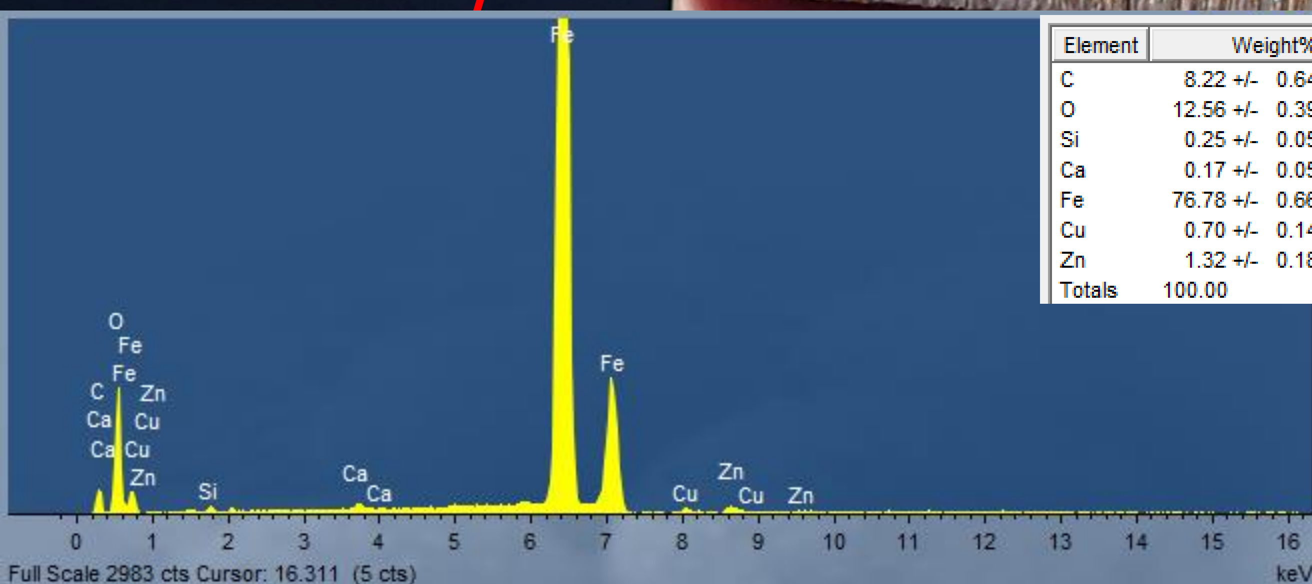
Flint D





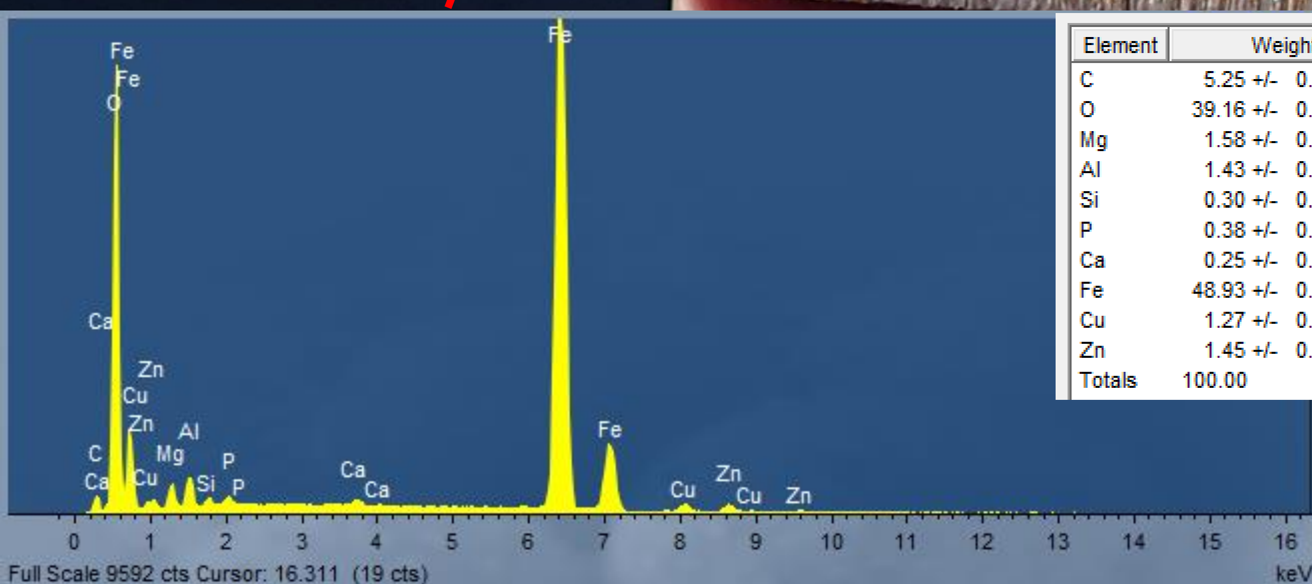
Element	Weight%
C	4.12 +/- 0.38
O	31.60 +/- 0.34
Mg	0.29 +/- 0.07
Al	0.23 +/- 0.05
Si	0.51 +/- 0.05
P	0.27 +/- 0.05
Ca	2.46 +/- 0.07
Fe	58.43 +/- 0.39
Cu	0.68 +/- 0.10
Zn	1.40 +/- 0.13
Totals	100.00

Flint D



Element	Weight%
C	8.22 +/- 0.64
O	12.56 +/- 0.39
Si	0.25 +/- 0.05
Ca	0.17 +/- 0.05
Fe	76.78 +/- 0.66
Cu	0.70 +/- 0.14
Zn	1.32 +/- 0.18
Totals	100.00

Flint D



Element	Weight%
C	5.25 +/- 0.36
O	39.16 +/- 0.31
Mg	1.58 +/- 0.09
Al	1.43 +/- 0.07
Si	0.30 +/- 0.05
P	0.38 +/- 0.05
Ca	0.25 +/- 0.04
Fe	48.93 +/- 0.31
Cu	1.27 +/- 0.10
Zn	1.45 +/- 0.11
Totals	100.00

Attachment 2:

Laboratory Testing Results:

1910 Montclair

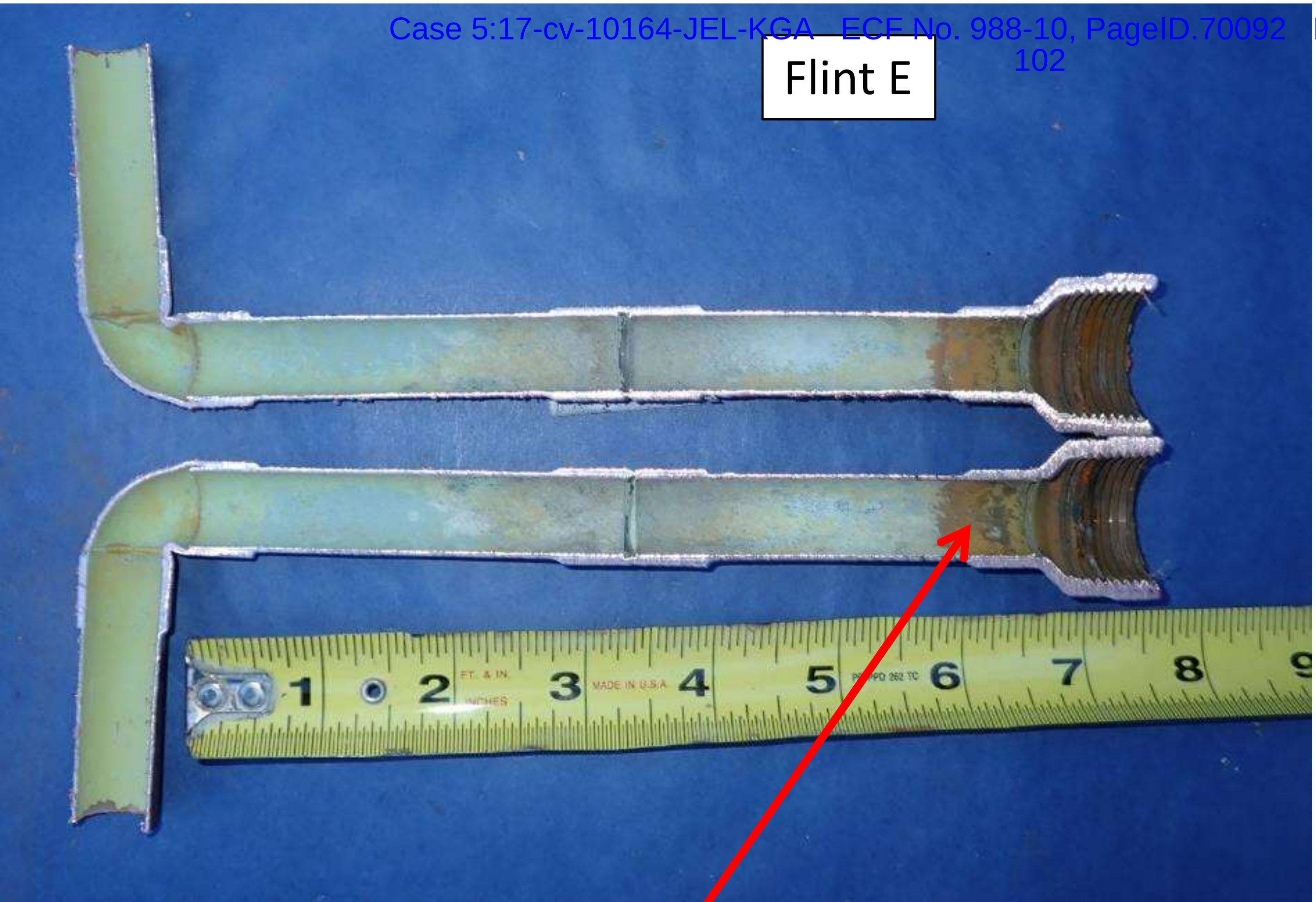
Project No: 22004
Date: Feb. 21, 2022
Client: REED
Project Name /Description: 1910 Montclair, Flint

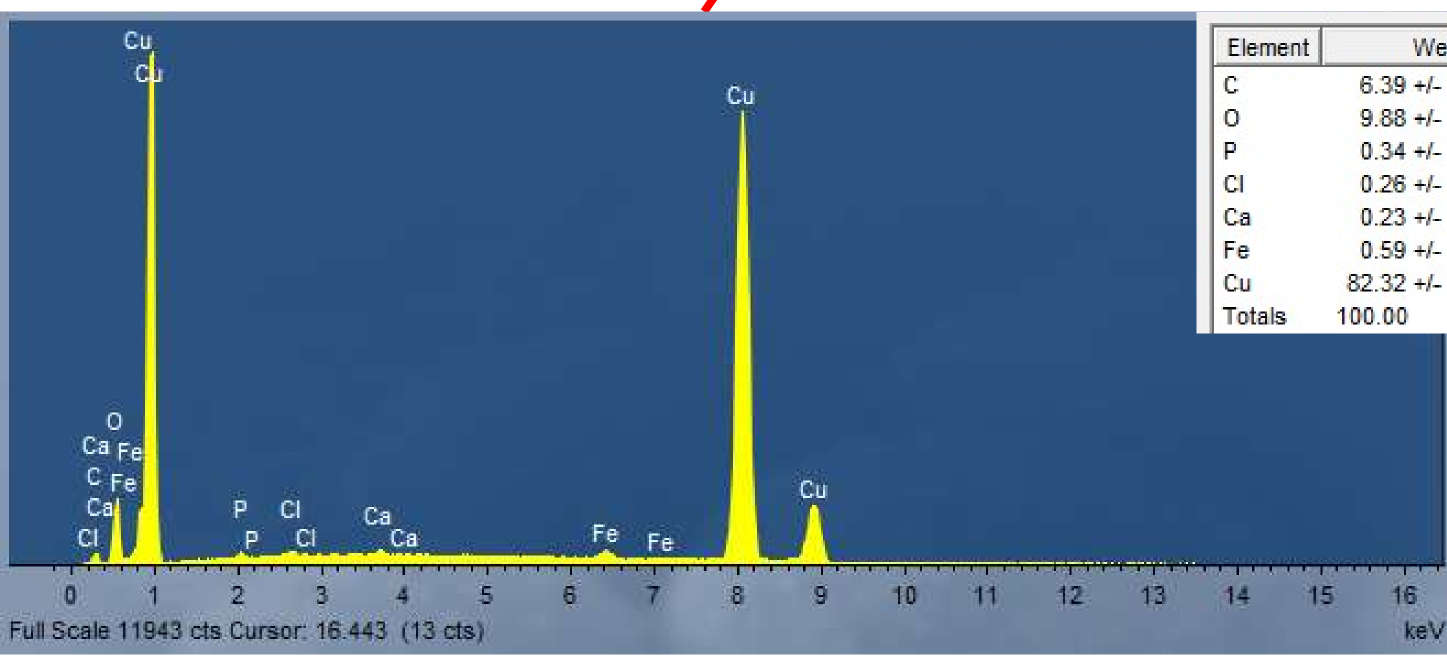
Notes & Remarks:

The analysis was performed by scanning electron microscopy with energy dispersive spectroscopy (SEM-EDS). EDS provides semi-quantitative elemental analysis of materials in a scanning electron microscope based on characteristic energies of x-rays produced by the electron beam. EDS can normally detect elements with atomic number 4 (Beryllium) and above at concentrations as low as approximately 0.1 weight percent. As performed in this examination, EDS cannot detect the elements hydrogen, helium and lithium.

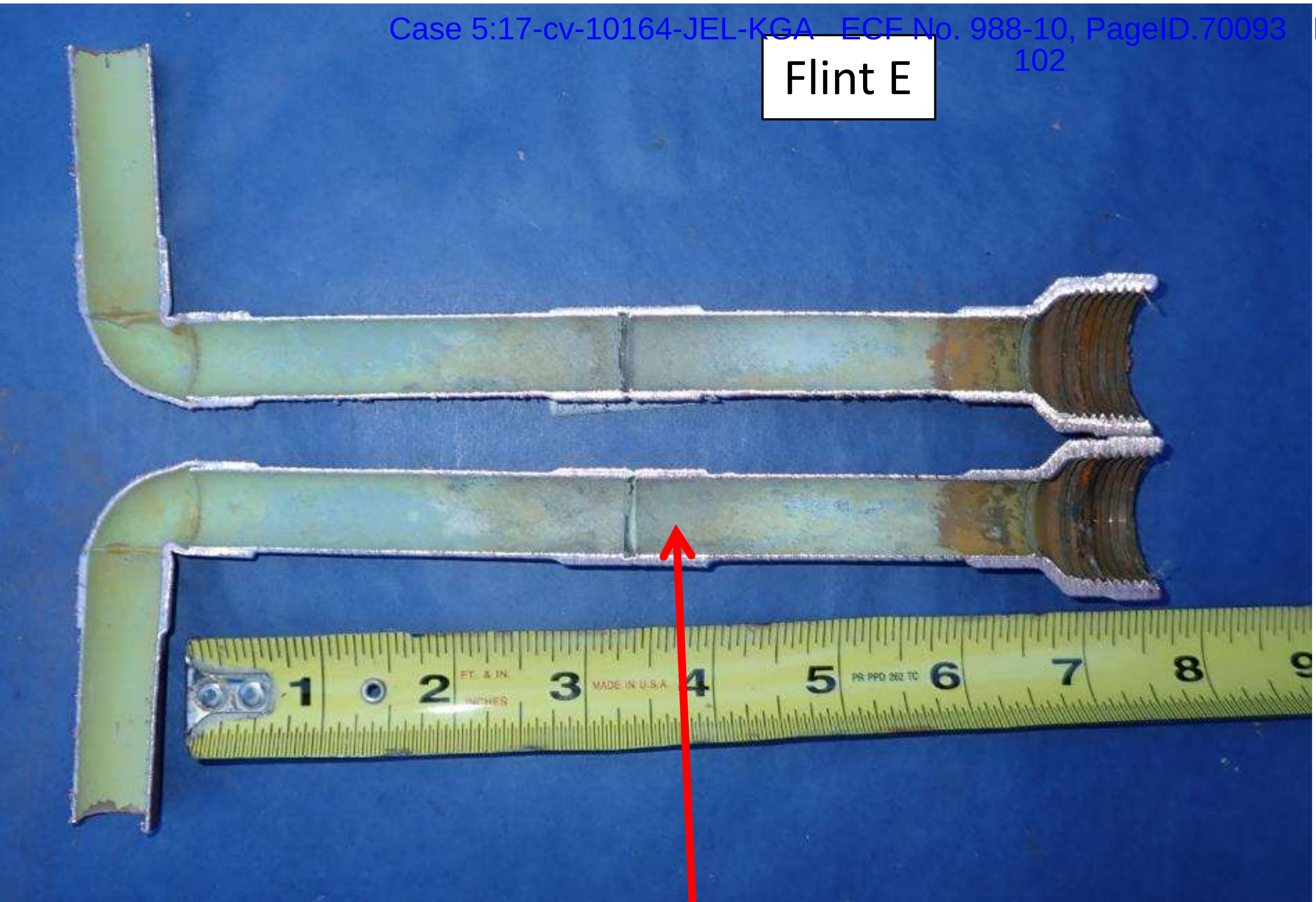
Christensen Materials Engineering
89 Stephanie Lane
Alamo, CA 94507
925-930-7222

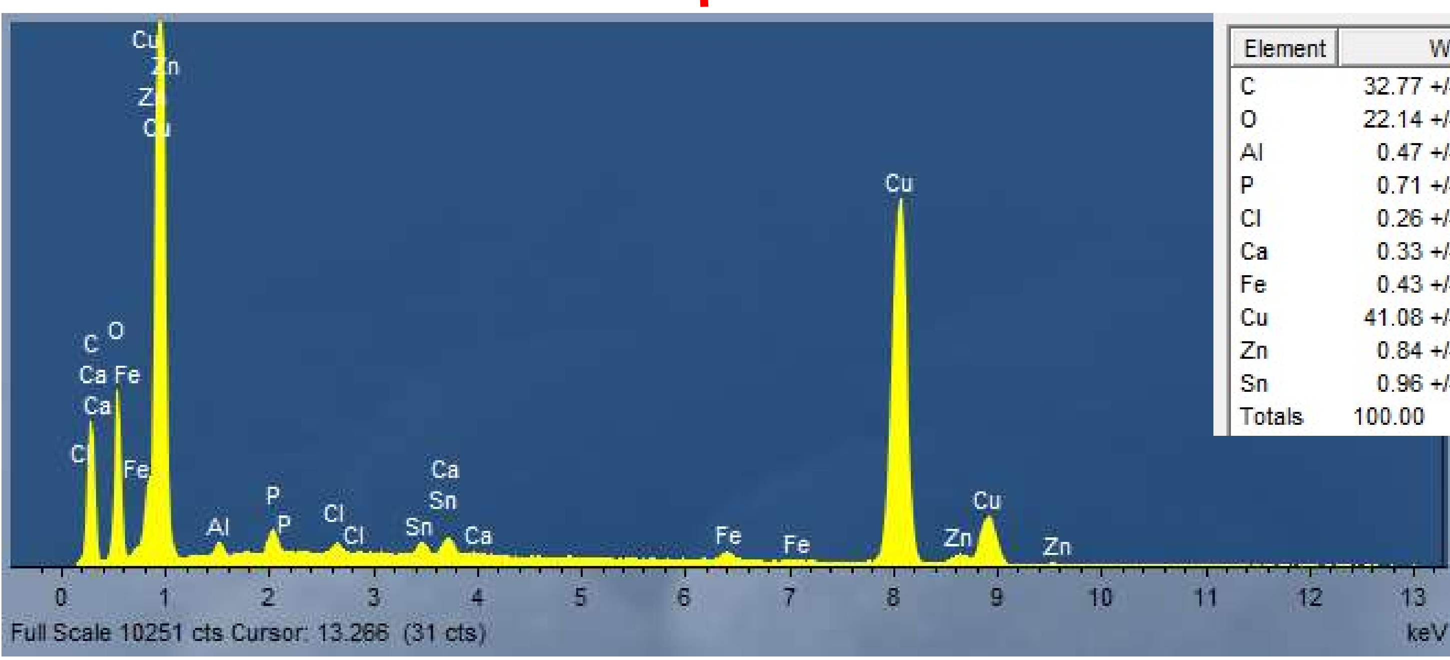
Flint E



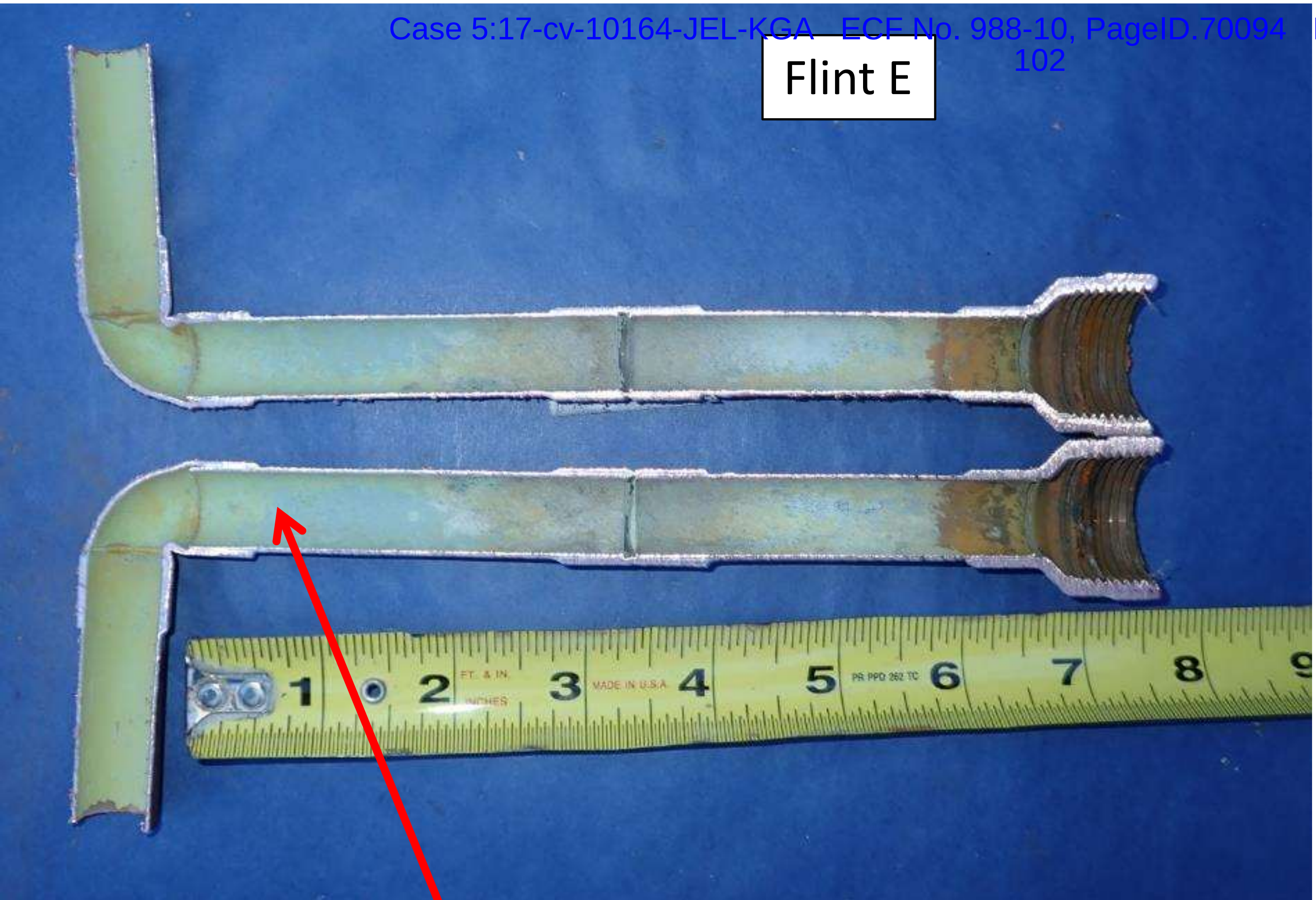


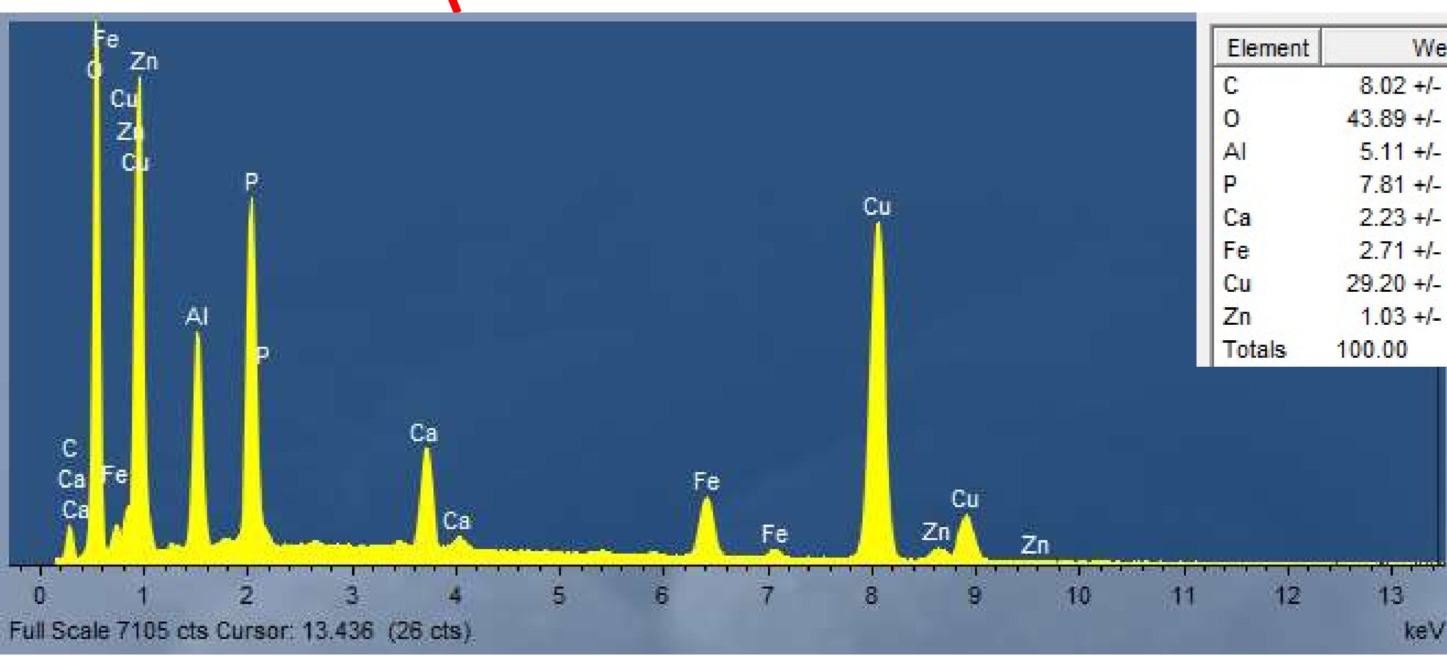
Element	Weight%
C	6.39 +/- 0.52
O	9.88 +/- 0.25
P	0.34 +/- 0.06
Cl	0.26 +/- 0.05
Ca	0.23 +/- 0.04
Fe	0.59 +/- 0.06
Cu	82.32 +/- 0.52
Totals	100.00



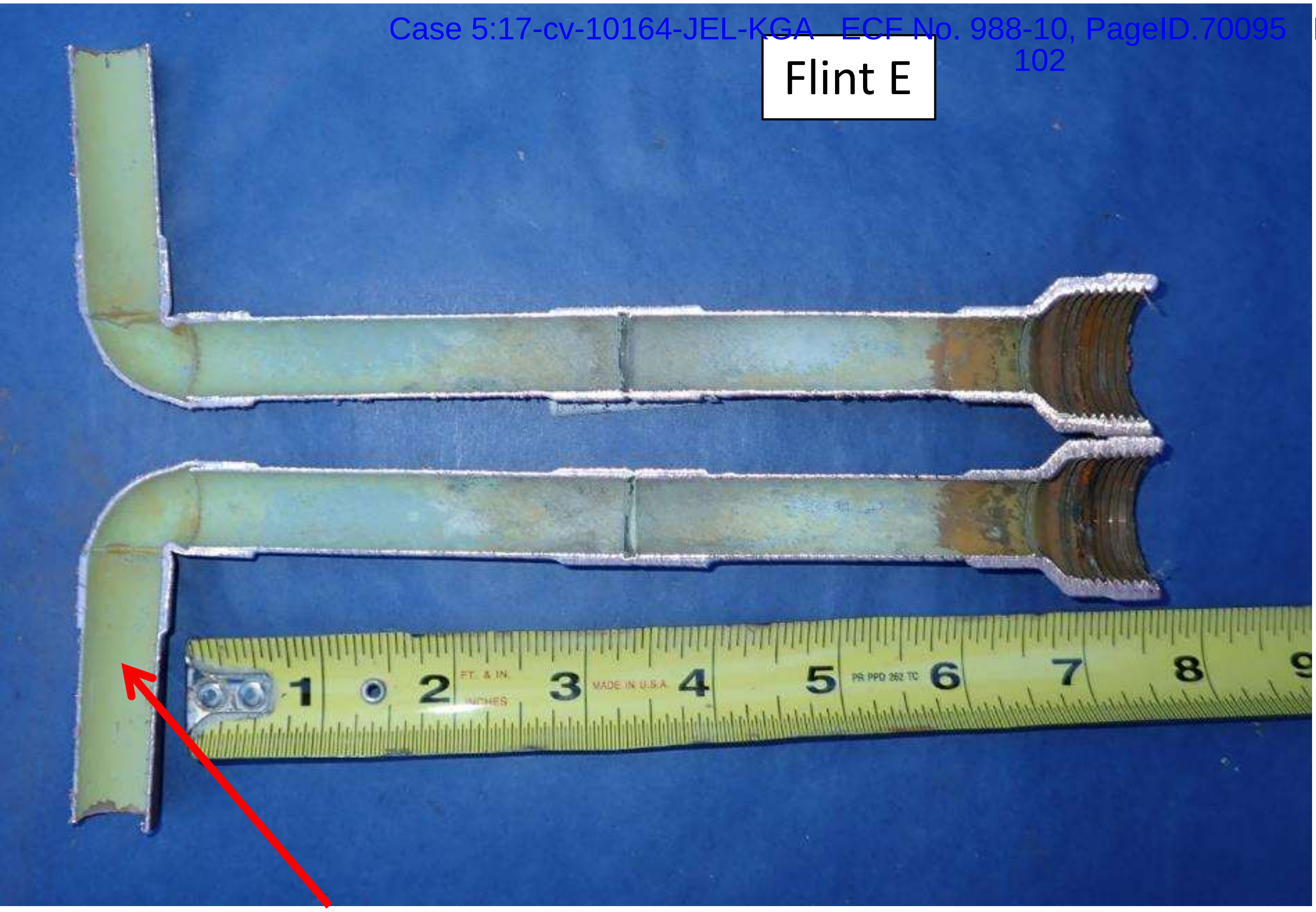


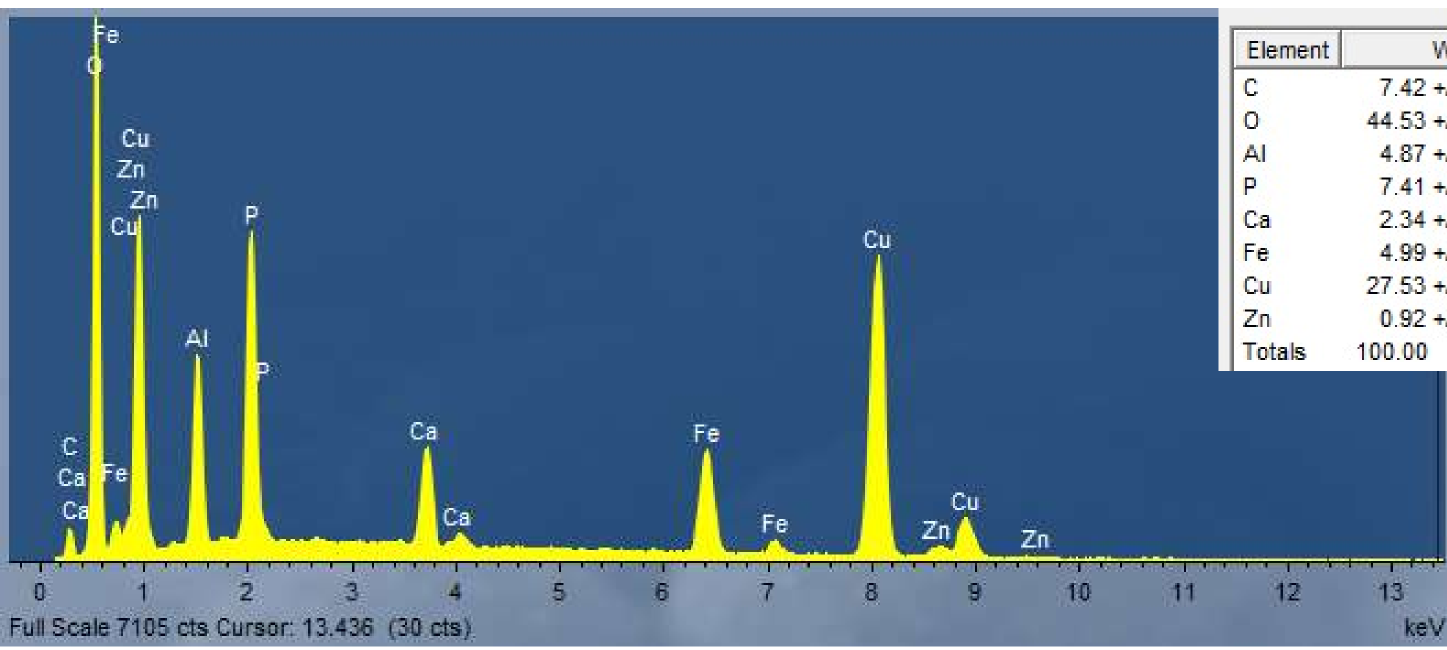
Element	Weight%
C	32.77 +/- 0.47
O	22.14 +/- 0.34
Al	0.47 +/- 0.04
P	0.71 +/- 0.05
Cl	0.26 +/- 0.03
Ca	0.33 +/- 0.04
Fe	0.43 +/- 0.04
Cu	41.08 +/- 0.36
Zn	0.84 +/- 0.10
Sn	0.96 +/- 0.09
Totals	100.00





Element	Weight%
C	8.02 +/- 0.42
O	43.89 +/- 0.34
Al	5.11 +/- 0.09
P	7.81 +/- 0.11
Ca	2.23 +/- 0.05
Fe	2.71 +/- 0.07
Cu	29.20 +/- 0.26
Zn	1.03 +/- 0.10
Totals	100.00

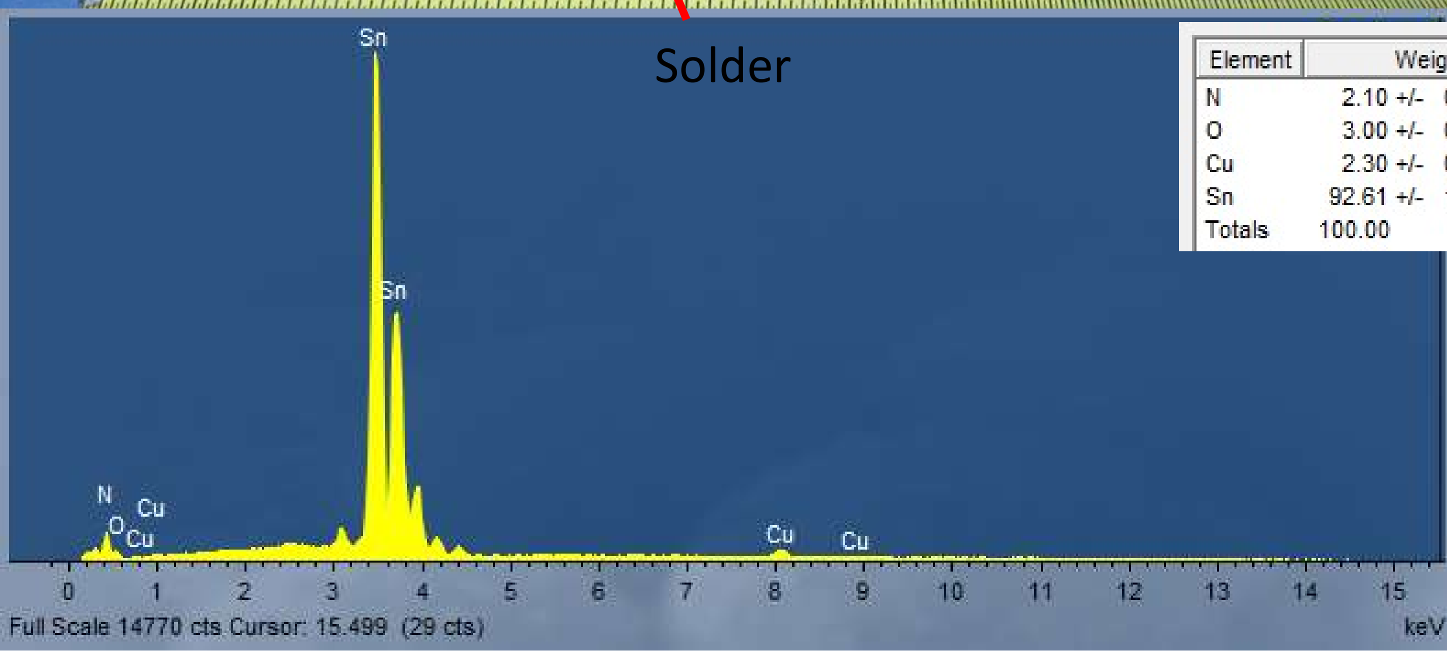




Element	Weight%
C	7.42 +/- 0.40
O	44.53 +/- 0.34
Al	4.87 +/- 0.09
P	7.41 +/- 0.11
Ca	2.34 +/- 0.05
Fe	4.99 +/- 0.09
Cu	27.53 +/- 0.25
Zn	0.92 +/- 0.11
Totals	100.00

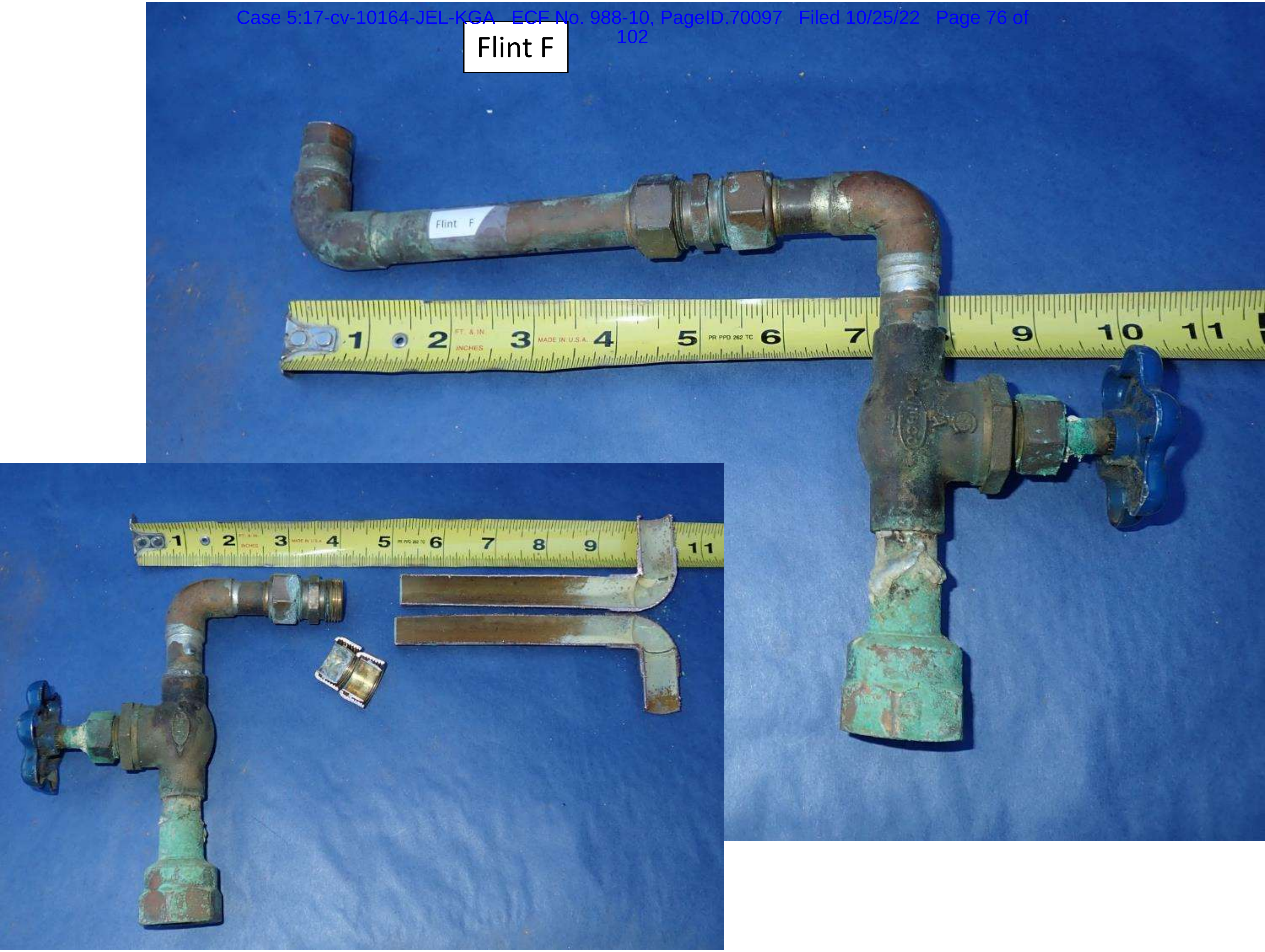
Flint E

Solder

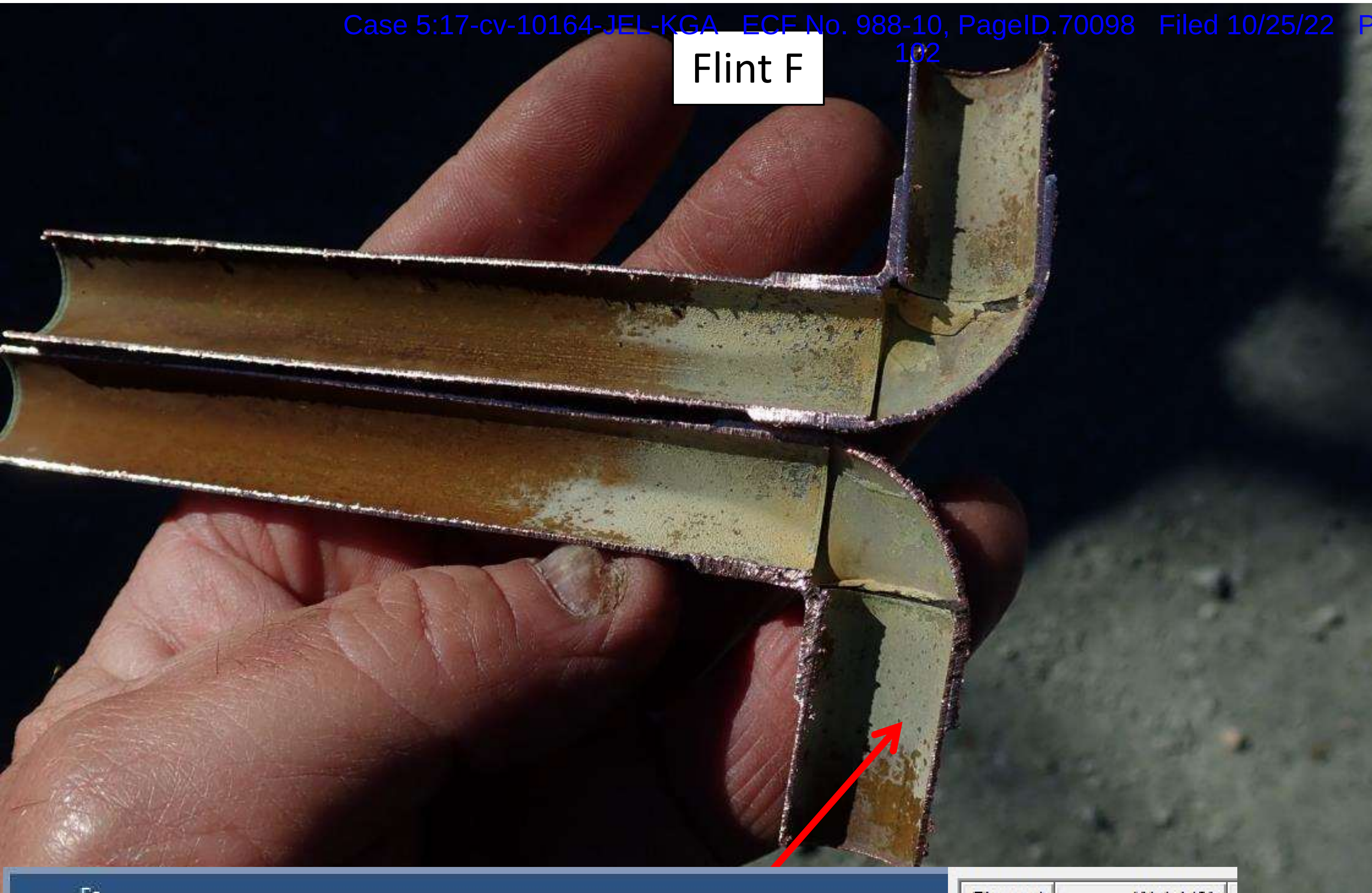


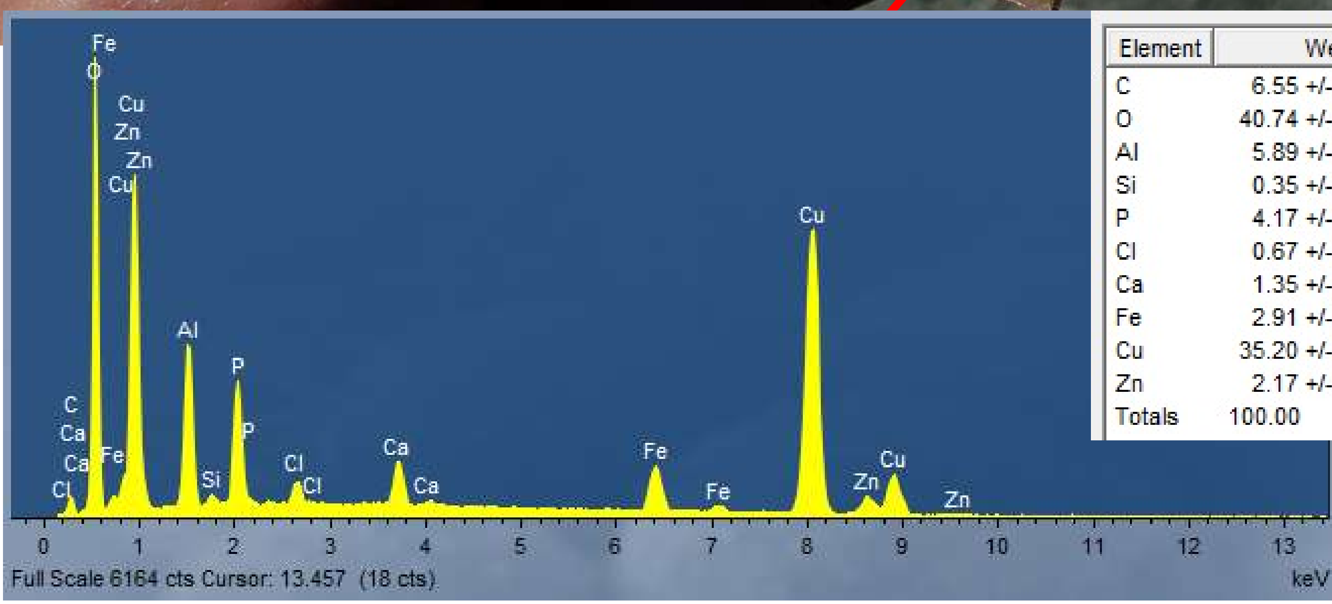
Element	Weight%
N	2.10 +/- 0.76
O	3.00 +/- 0.77
Cu	2.30 +/- 0.15
Sn	92.61 +/- 1.04
Totals	100.00

Flint F

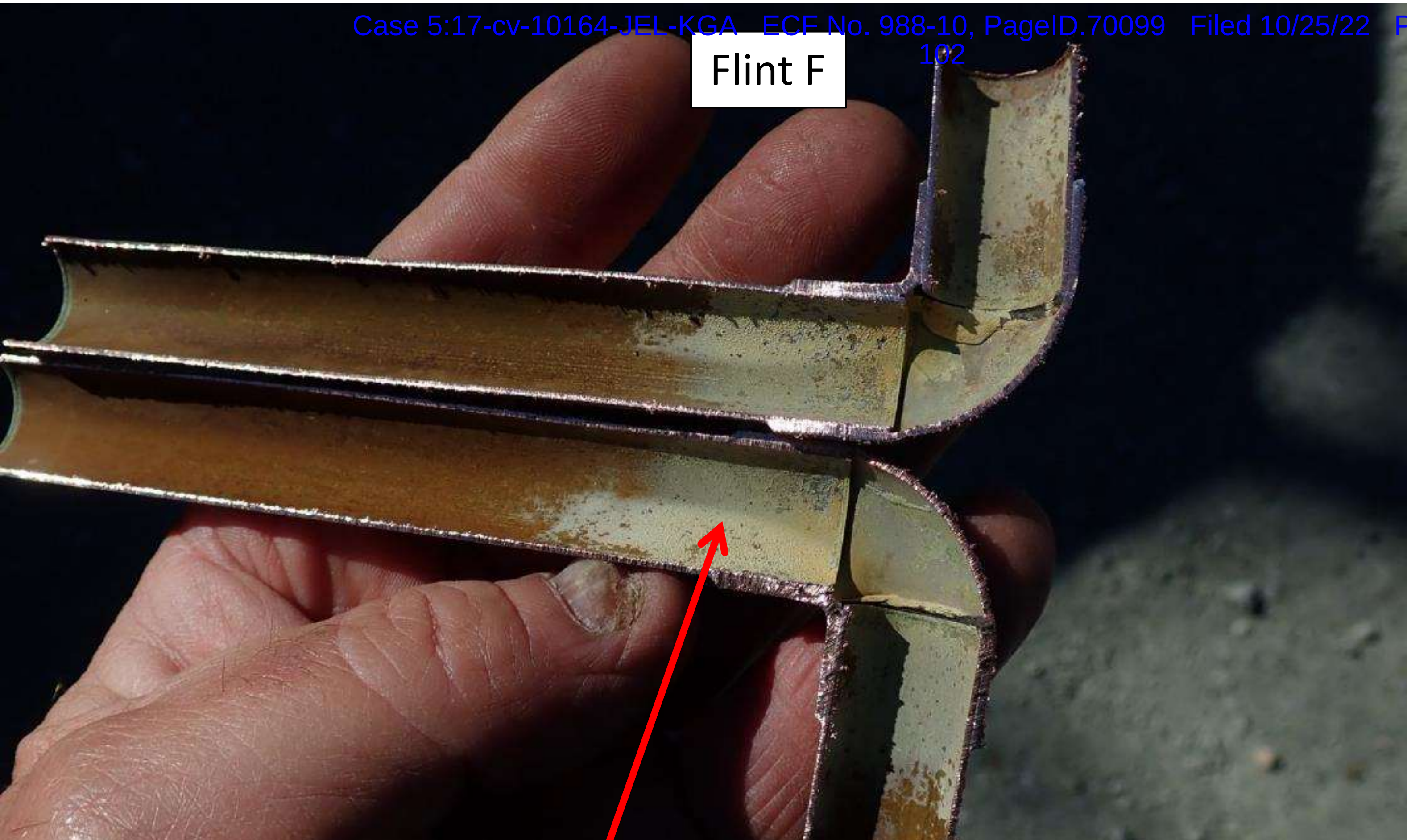


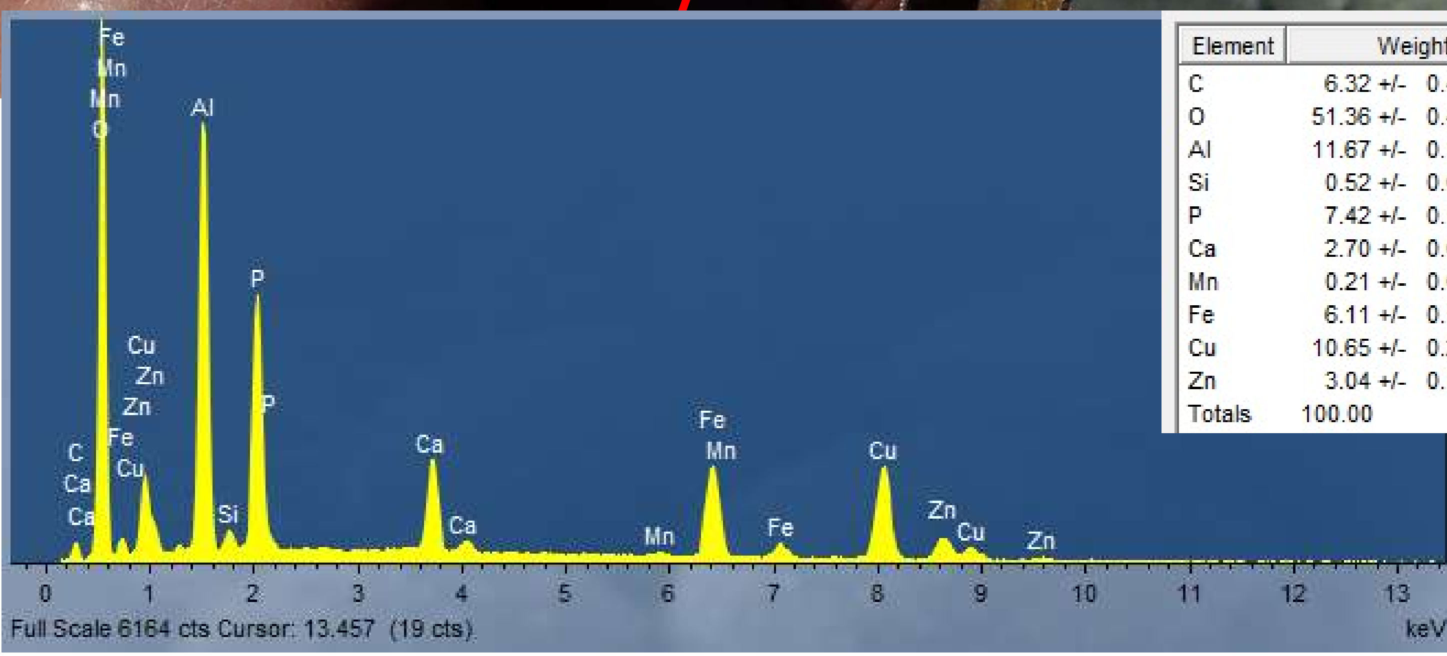
Flint F





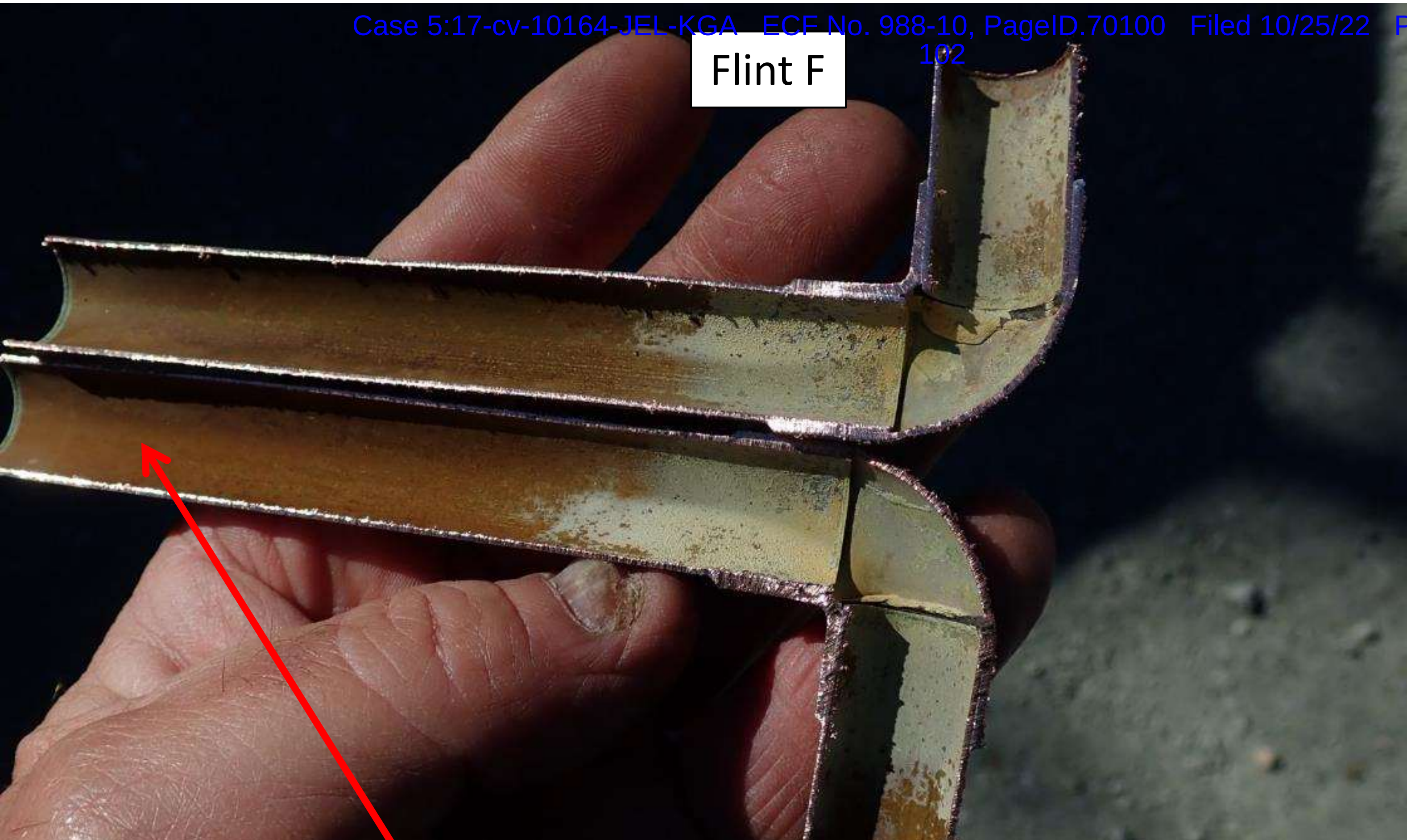
Element	Weight%
C	6.55 +/- 0.54
O	40.74 +/- 0.40
Al	5.89 +/- 0.12
Si	0.35 +/- 0.06
P	4.17 +/- 0.10
Cl	0.67 +/- 0.05
Ca	1.35 +/- 0.06
Fe	2.91 +/- 0.09
Cu	35.20 +/- 0.35
Zn	2.17 +/- 0.15
Totals	100.00

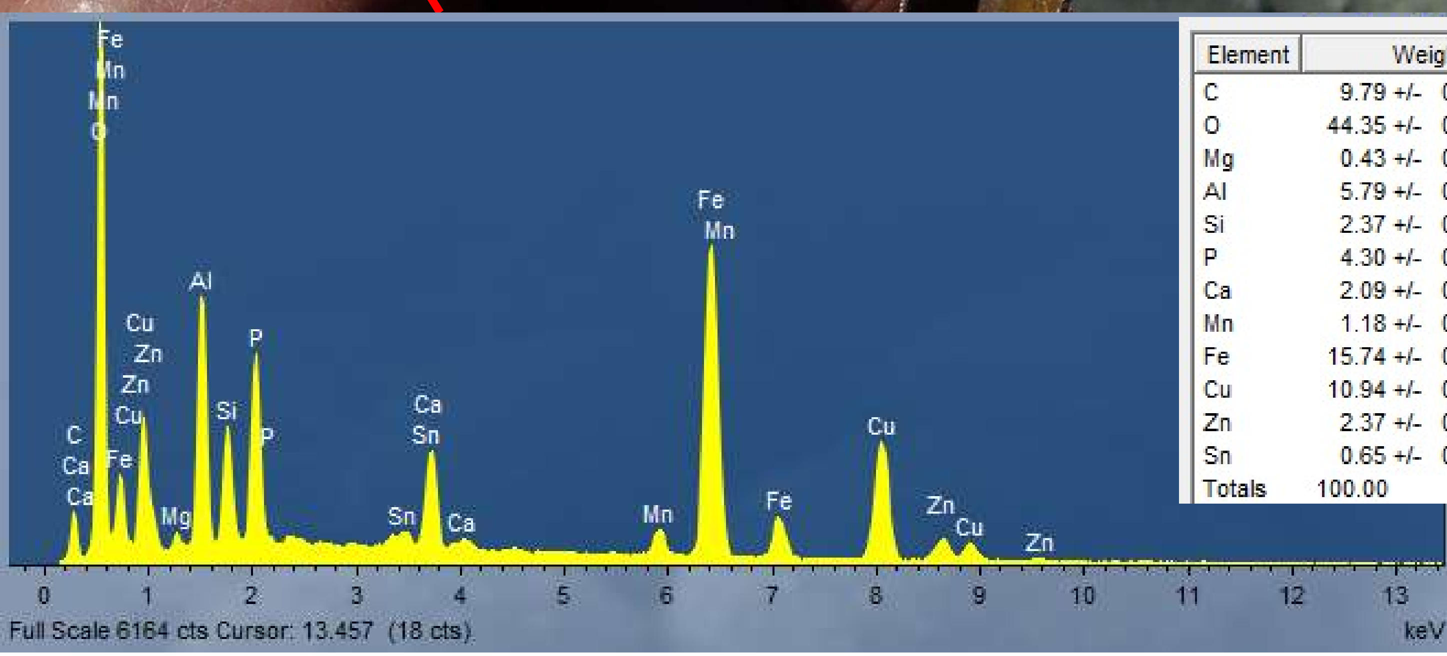




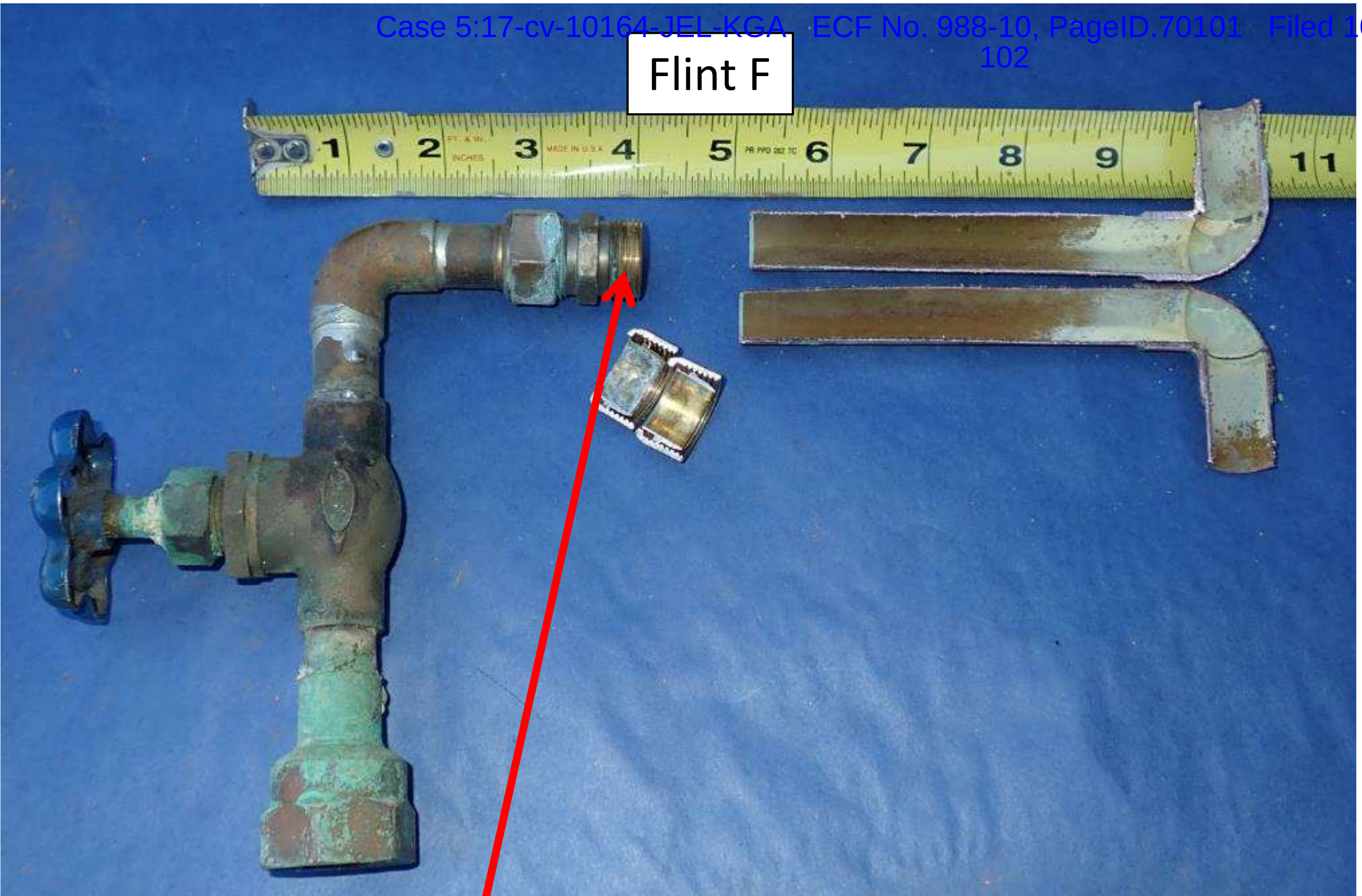
Element	Weight%
C	6.32 +/- 0.46
O	51.36 +/- 0.41
Al	11.67 +/- 0.15
Si	0.52 +/- 0.06
P	7.42 +/- 0.13
Ca	2.70 +/- 0.07
Mn	0.21 +/- 0.06
Fe	6.11 +/- 0.12
Cu	10.65 +/- 0.20
Zn	3.04 +/- 0.15
Totals	100.00

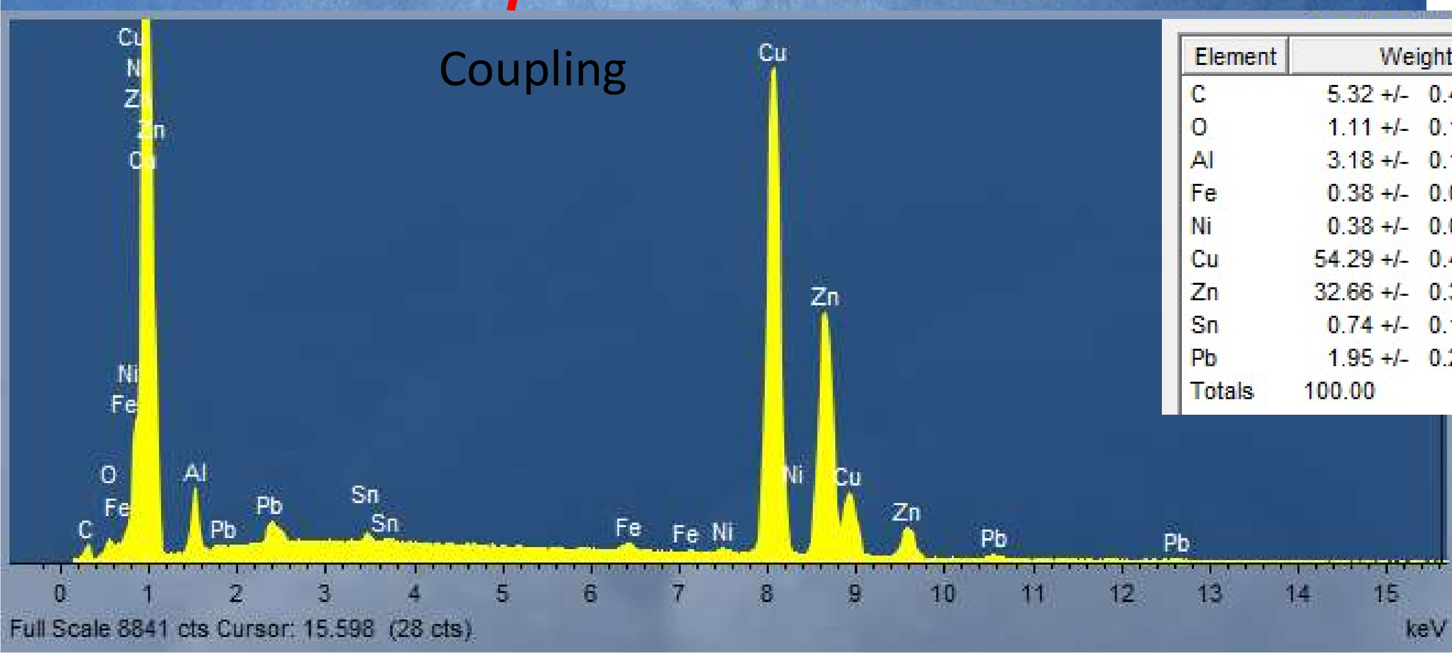
Flint F





Element	Weight%
C	9.79 +/- 0.45
O	44.35 +/- 0.38
Mg	0.43 +/- 0.06
Al	5.79 +/- 0.10
Si	2.37 +/- 0.07
P	4.30 +/- 0.09
Ca	2.09 +/- 0.06
Mn	1.18 +/- 0.06
Fe	15.74 +/- 0.18
Cu	10.94 +/- 0.18
Zn	2.37 +/- 0.13
Sn	0.65 +/- 0.11
Totals	100.00





Element	Weight%
C	5.32 +/- 0.49
O	1.11 +/- 0.17
Al	3.18 +/- 0.11
Fe	0.38 +/- 0.06
Ni	0.38 +/- 0.07
Cu	54.29 +/- 0.40
Zn	32.66 +/- 0.31
Sn	0.74 +/- 0.11
Pb	1.95 +/- 0.20
Totals	100.00

Flint G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FT. & IN.
INCHES
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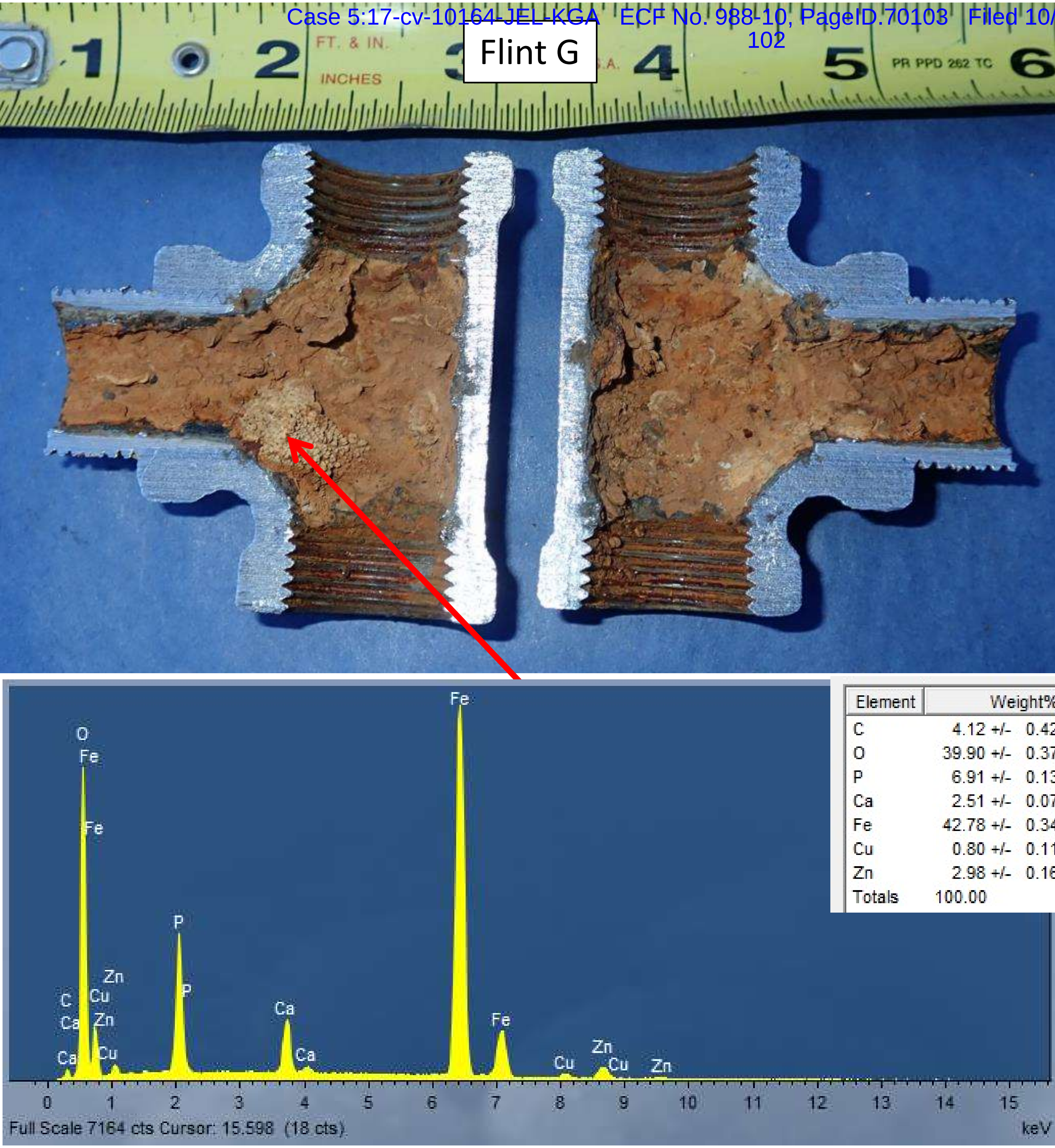
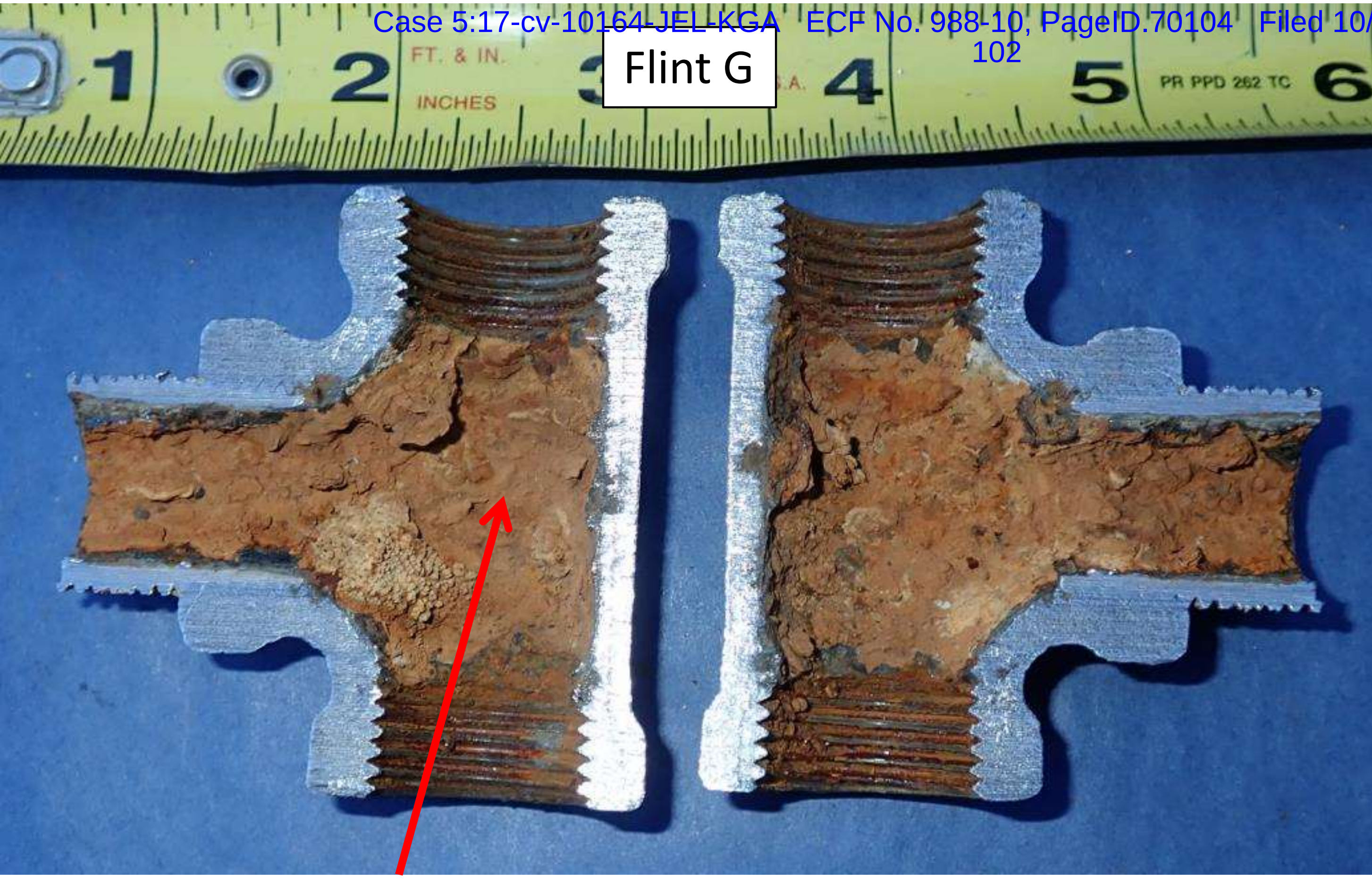
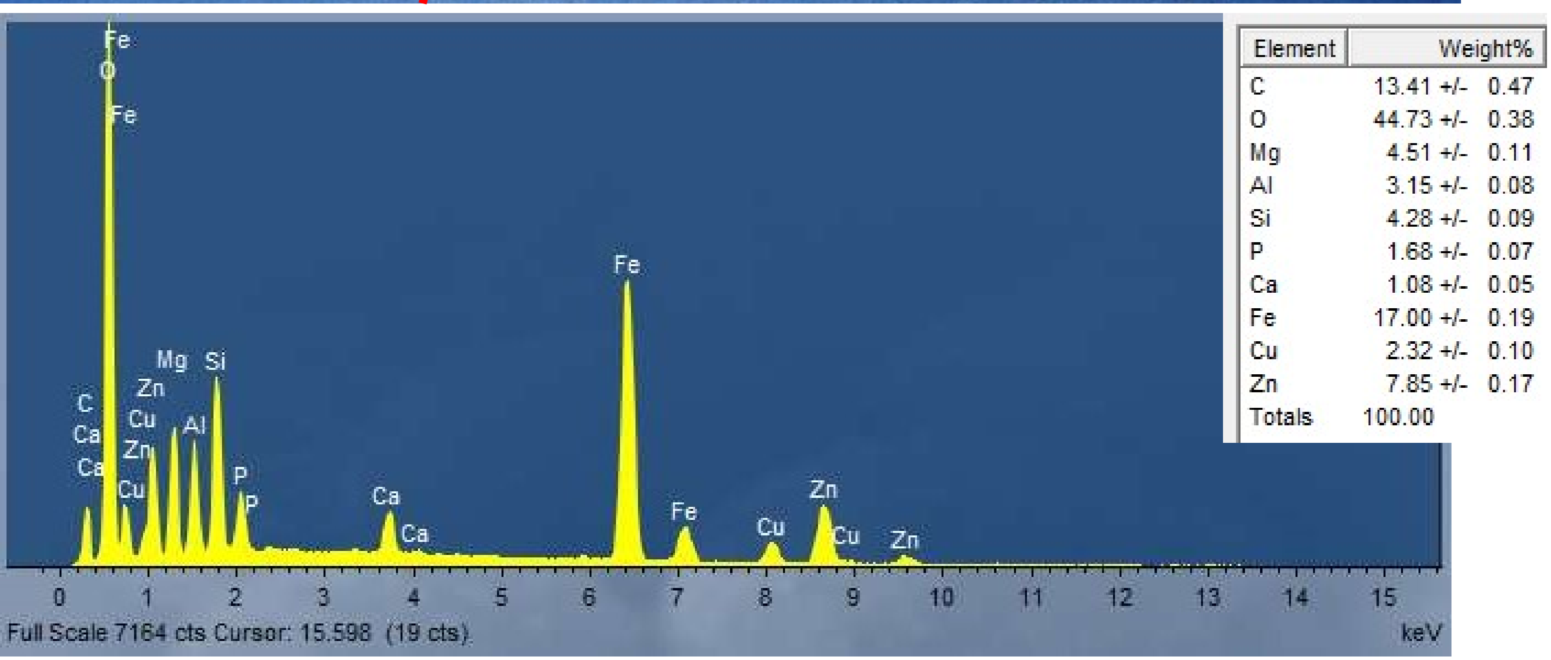
PR PPD 262 TC

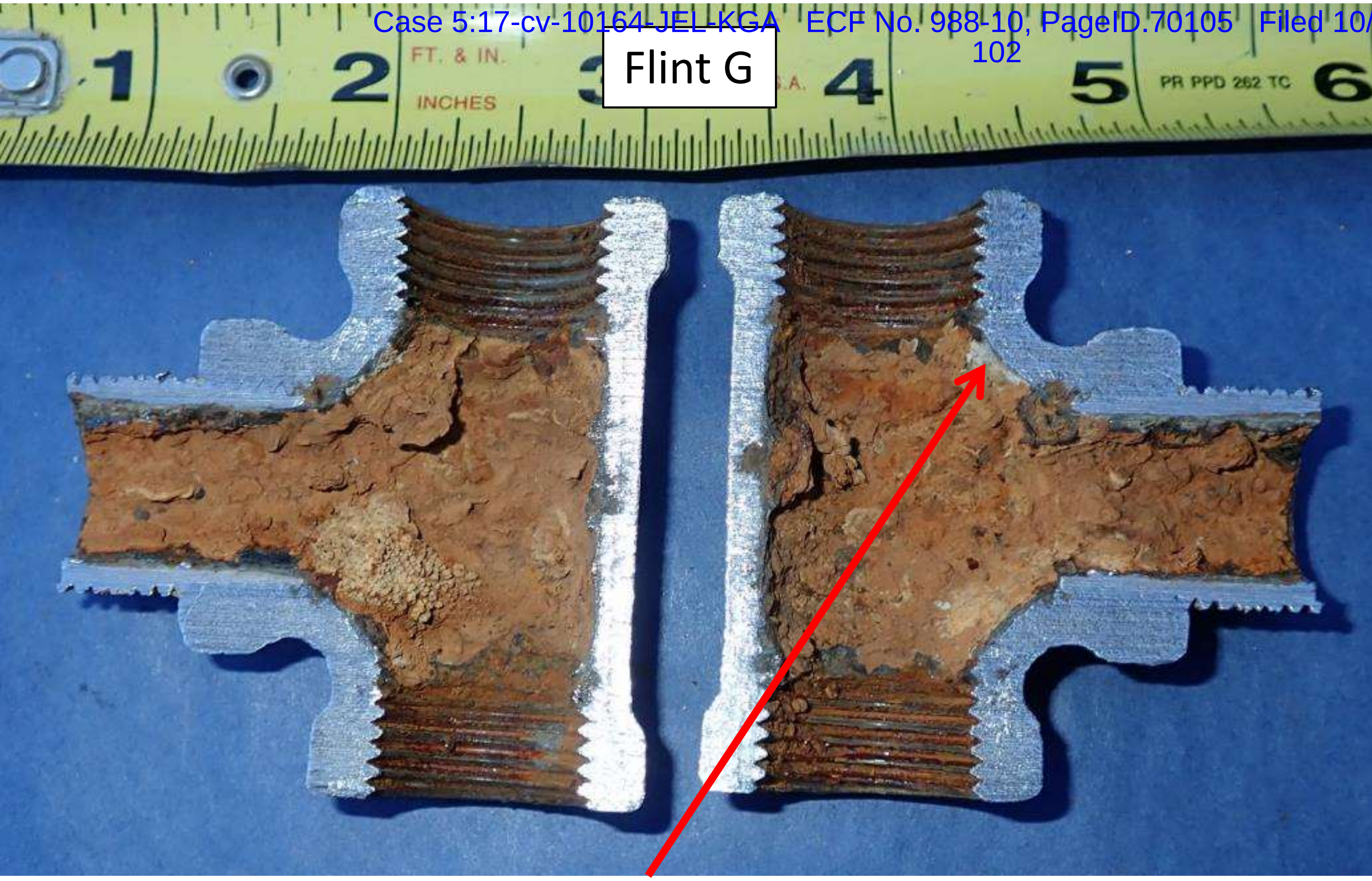


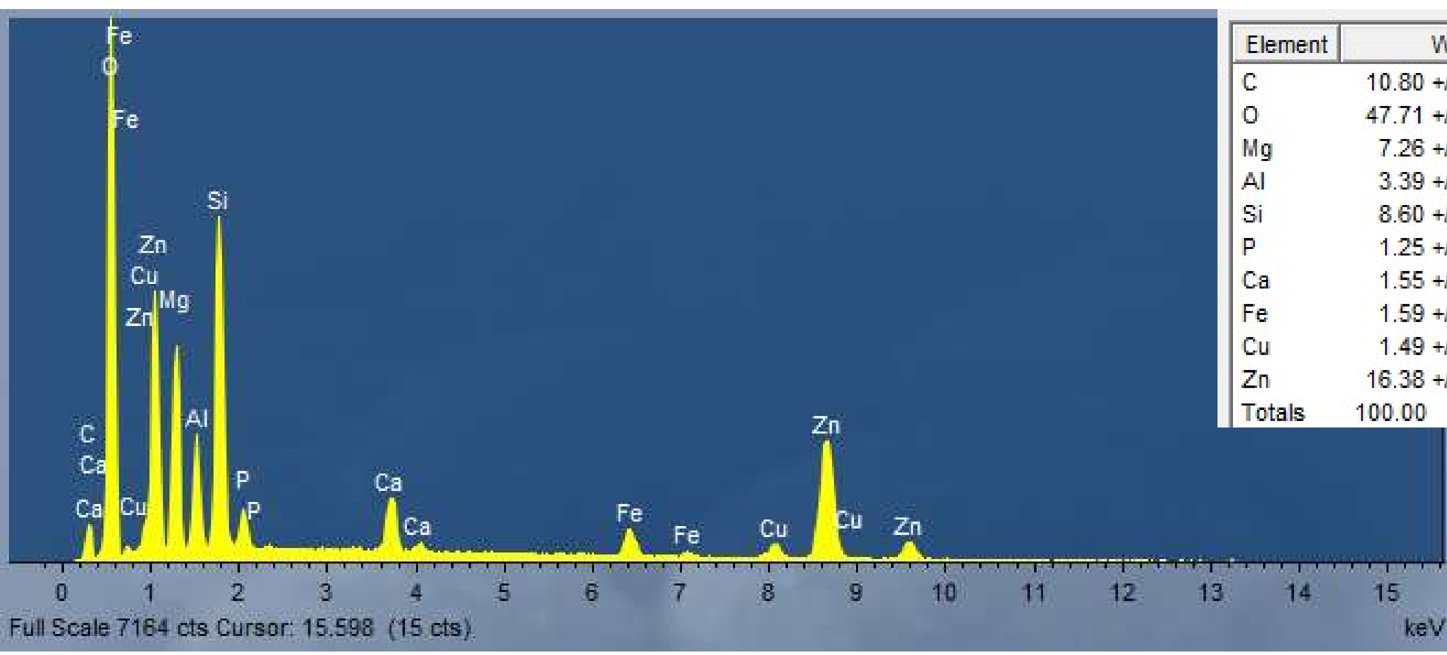
Element	Weight%
C	4.12 +/- 0.42
O	39.90 +/- 0.37
P	6.91 +/- 0.13
Ca	2.51 +/- 0.07
Fe	42.78 +/- 0.34
Cu	0.80 +/- 0.11
Zn	2.98 +/- 0.16
Totals	100.00



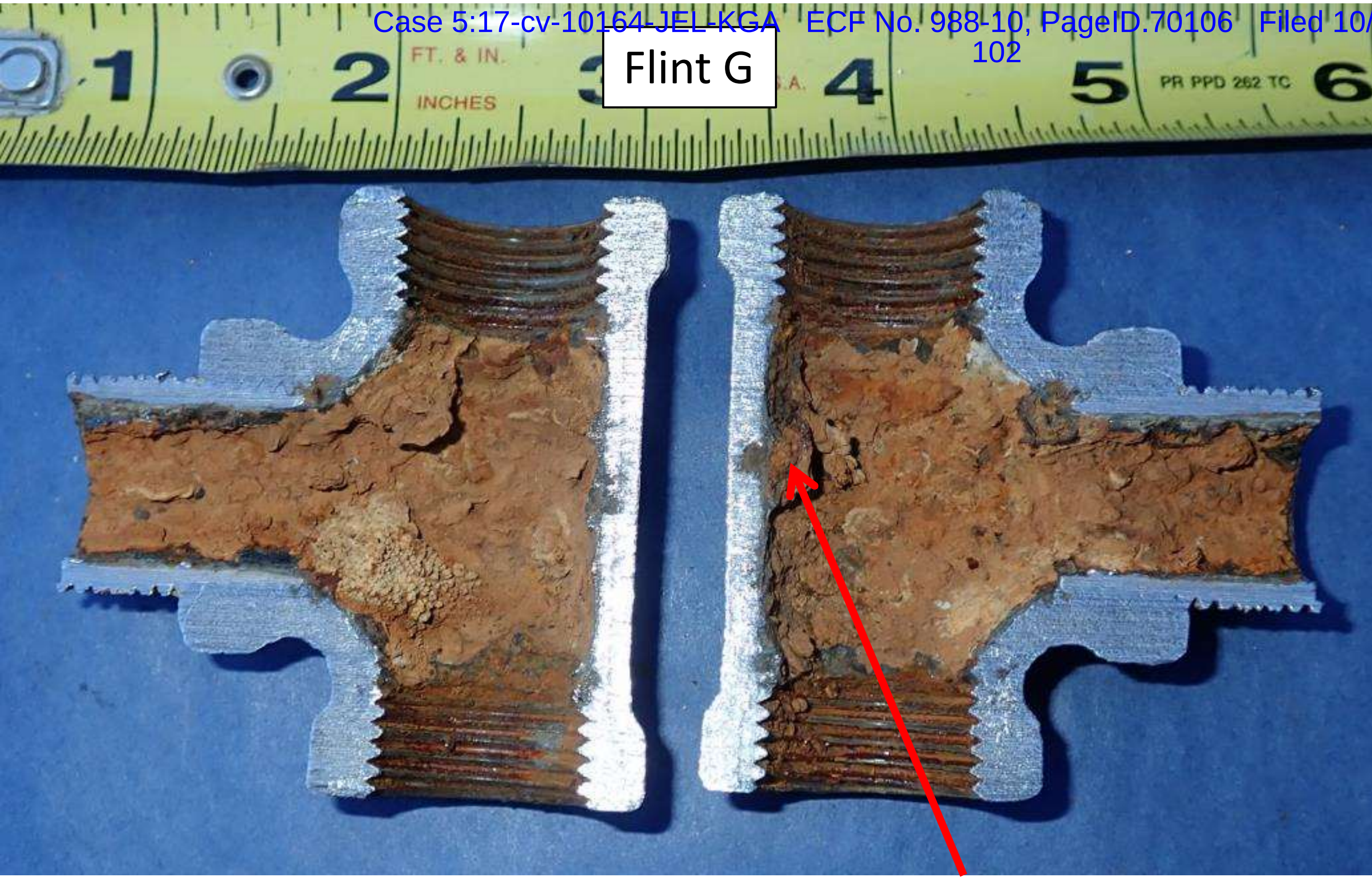


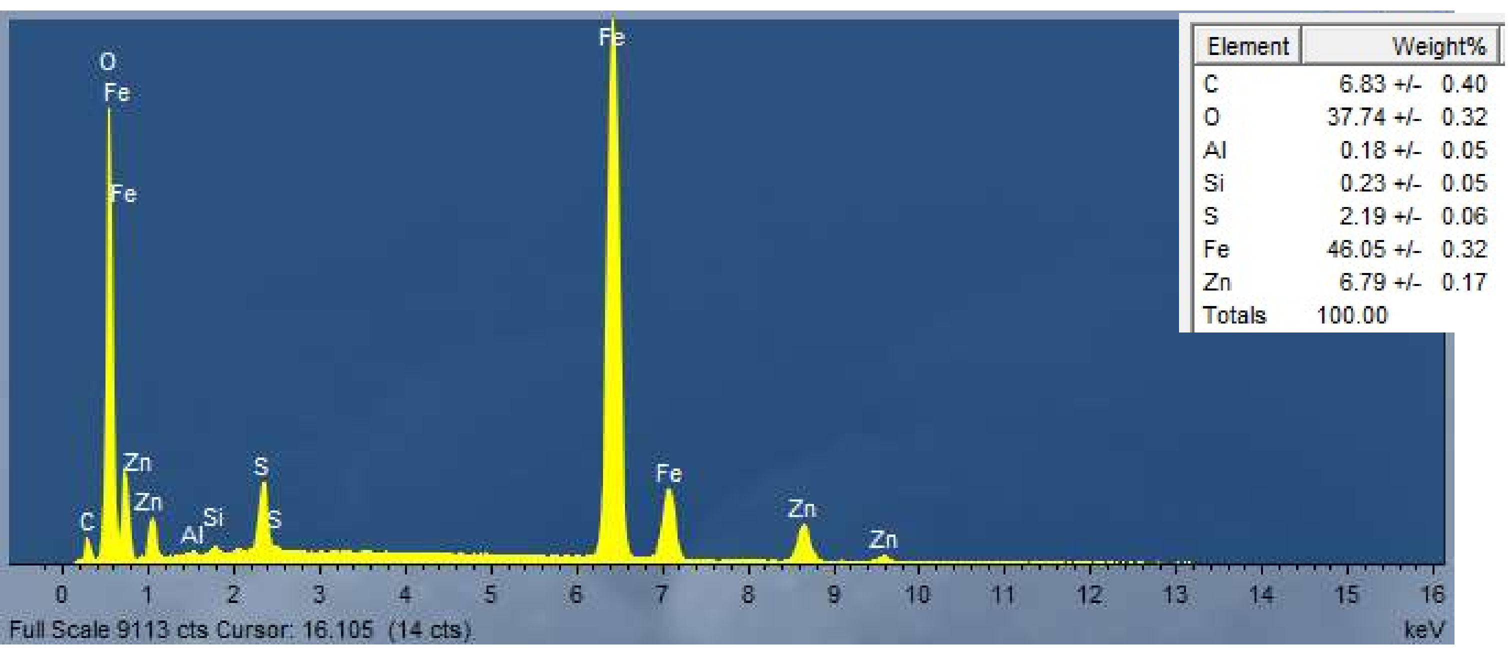
Element	Weight%
C	13.41 +/- 0.47
O	44.73 +/- 0.38
Mg	4.51 +/- 0.11
Al	3.15 +/- 0.08
Si	4.28 +/- 0.09
P	1.68 +/- 0.07
Ca	1.08 +/- 0.05
Fe	17.00 +/- 0.19
Cu	2.32 +/- 0.10
Zn	7.85 +/- 0.17
Totals	100.00





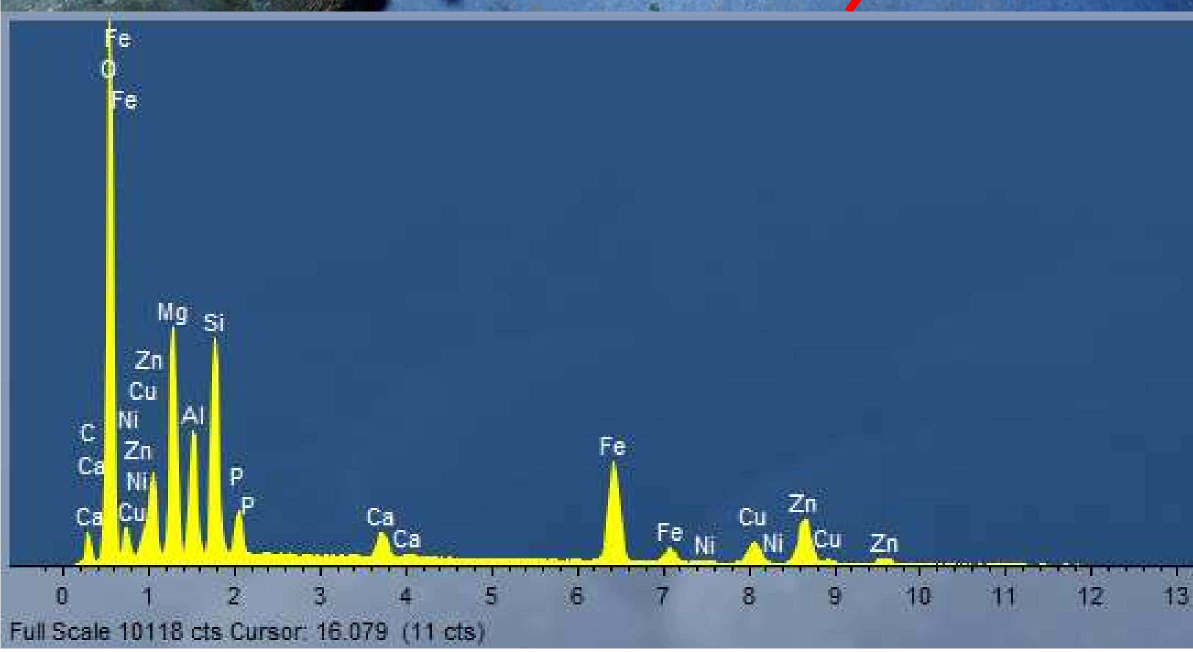
Element	Weight%
C	10.80 +/- 0.49
O	47.71 +/- 0.40
Mg	7.26 +/- 0.13
Al	3.39 +/- 0.09
Si	8.60 +/- 0.12
P	1.25 +/- 0.06
Ca	1.55 +/- 0.05
Fe	1.59 +/- 0.07
Cu	1.49 +/- 0.09
Zn	16.38 +/- 0.23
Totals	100.00



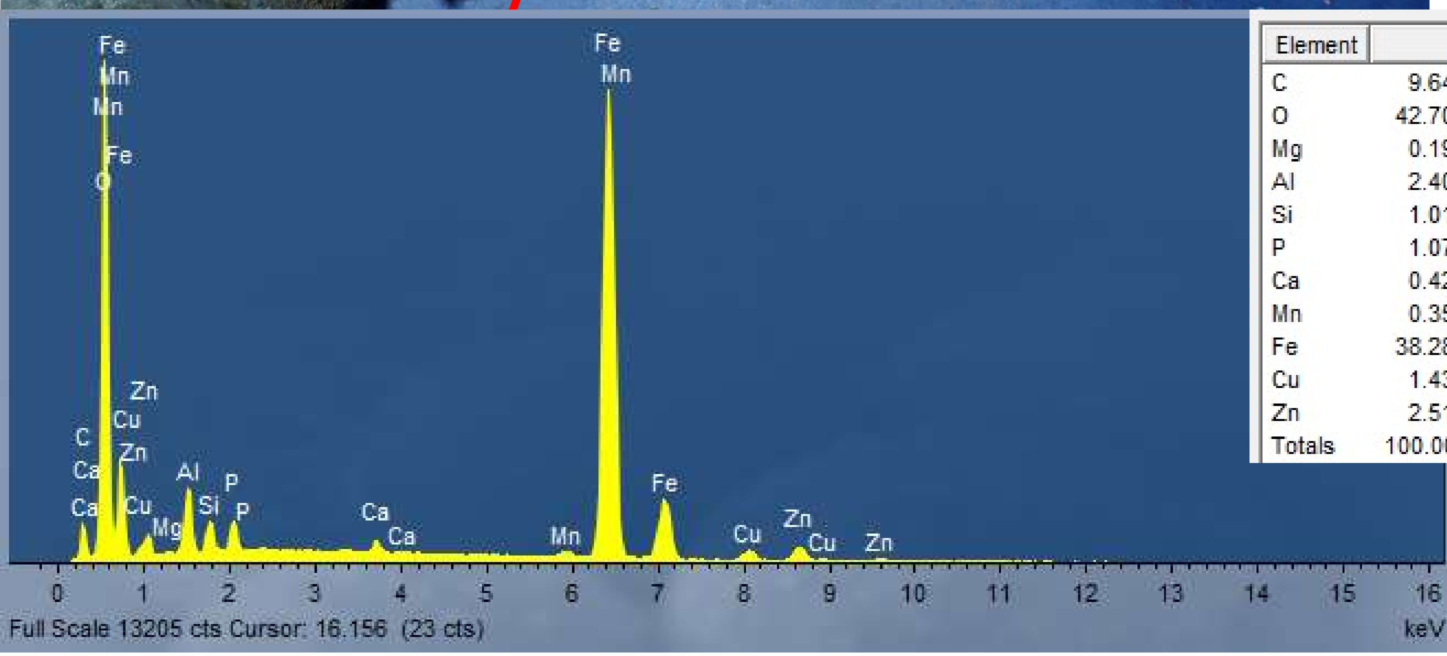


Element	Weight%
C	6.83 +/- 0.40
O	37.74 +/- 0.32
Al	0.18 +/- 0.05
Si	0.23 +/- 0.05
S	2.19 +/- 0.06
Fe	46.05 +/- 0.32
Zn	6.79 +/- 0.17
Totals	100.00

Flint H

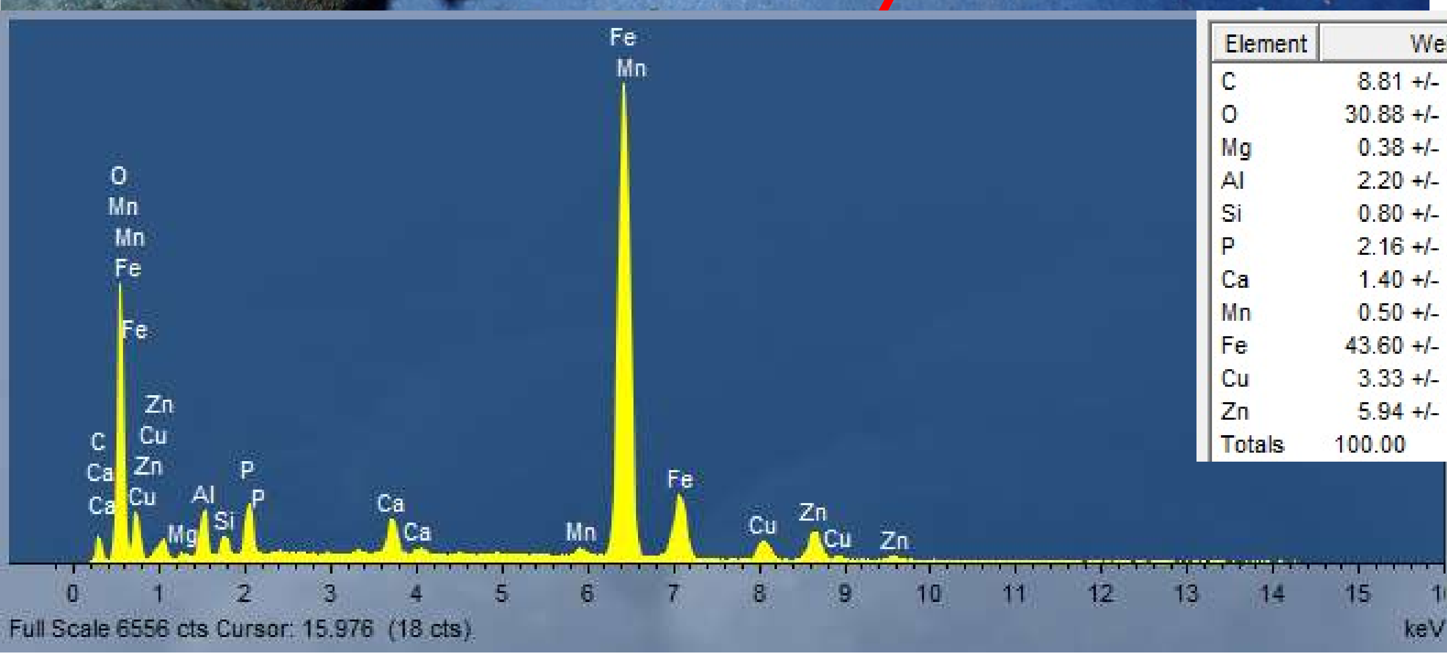


Element	Weight%
C	9.31 +/- 0.43
O	51.71 +/- 0.36
Mg	8.72 +/- 0.13
Al	4.06 +/- 0.08
Si	6.49 +/- 0.10
P	1.45 +/- 0.06
Ca	0.86 +/- 0.04
Fe	7.15 +/- 0.11
Ni	0.17 +/- 0.05
Cu	2.83 +/- 0.10
Zn	7.25 +/- 0.15
Totals	100.00

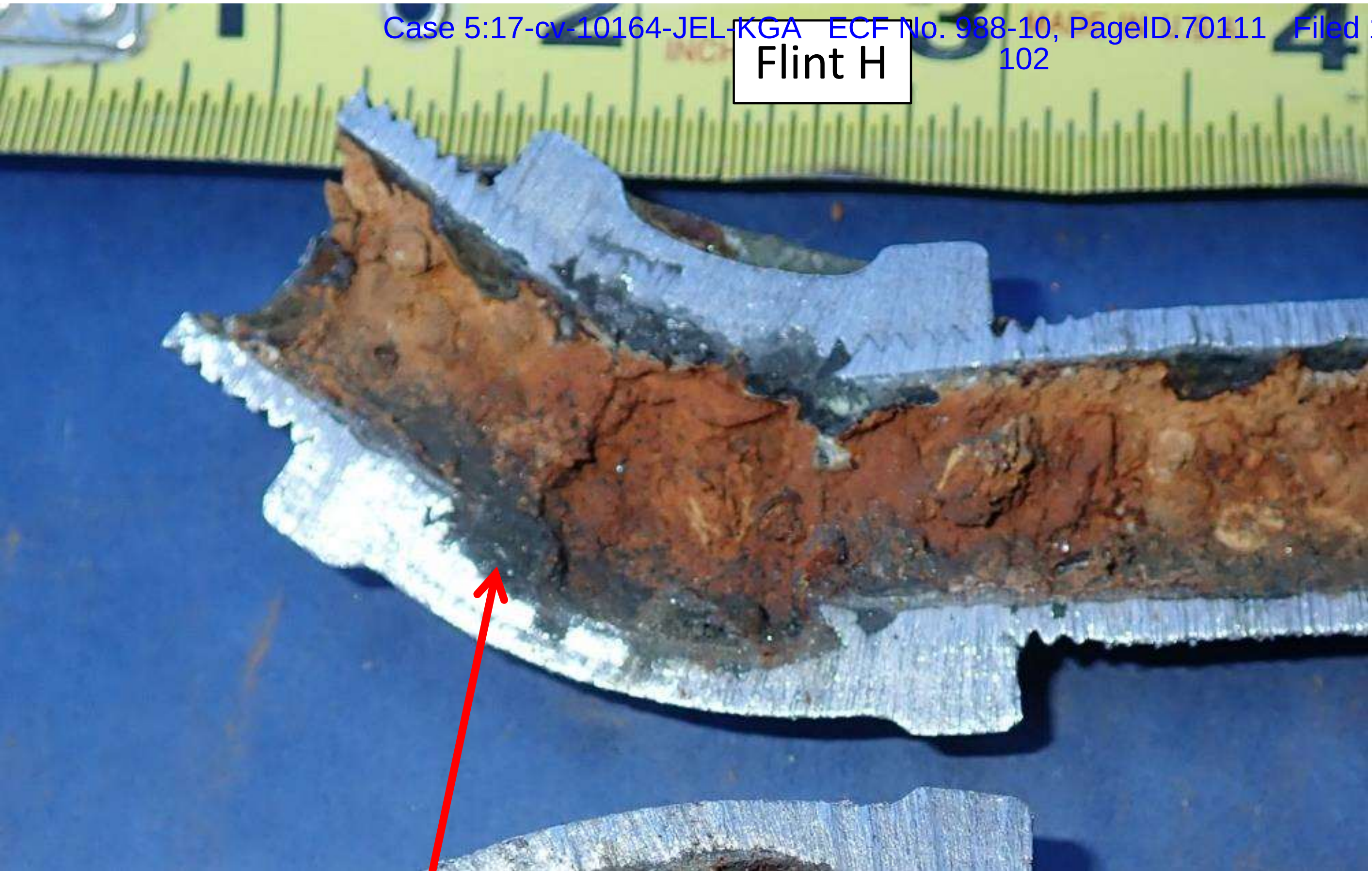


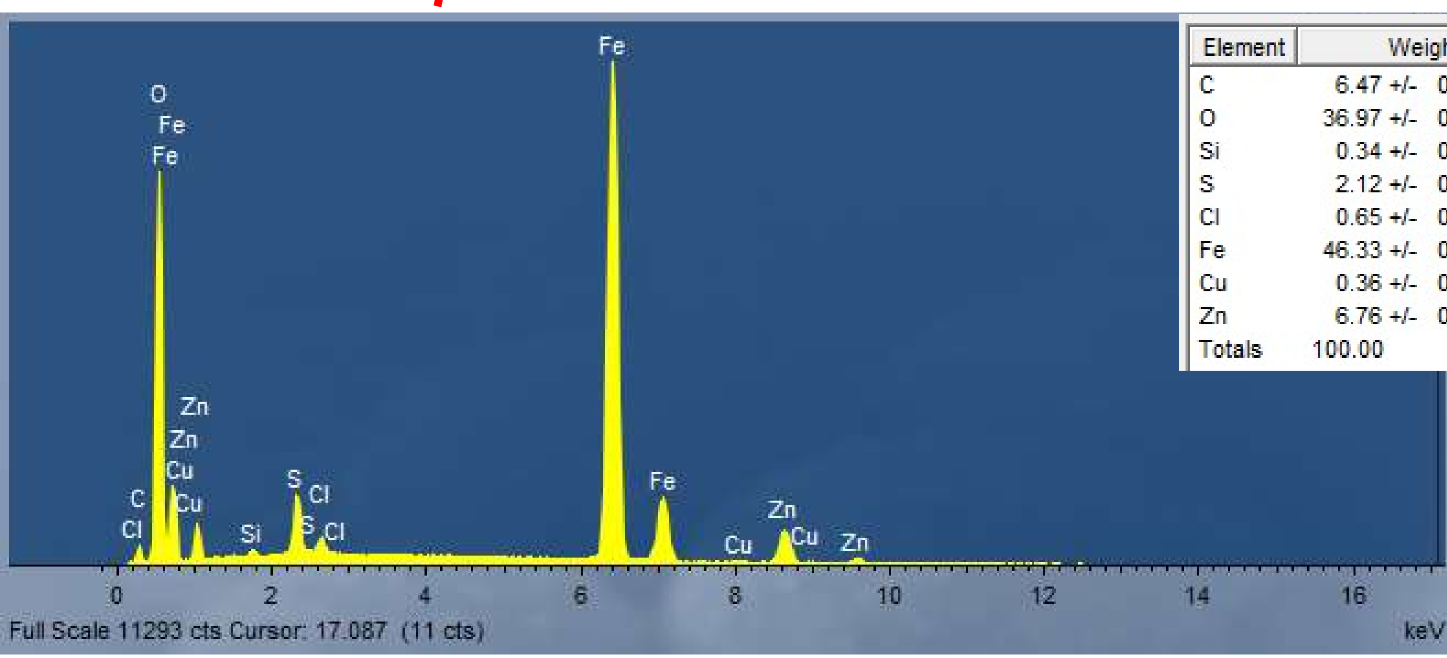
Element	Weight%
C	9.64 +/- 0.35
O	42.70 +/- 0.29
Mg	0.19 +/- 0.05
Al	2.40 +/- 0.06
Si	1.01 +/- 0.05
P	1.07 +/- 0.05
Ca	0.42 +/- 0.03
Mn	0.35 +/- 0.05
Fe	38.28 +/- 0.25
Cu	1.43 +/- 0.08
Zn	2.51 +/- 0.10
Totals	100.00

Flint H

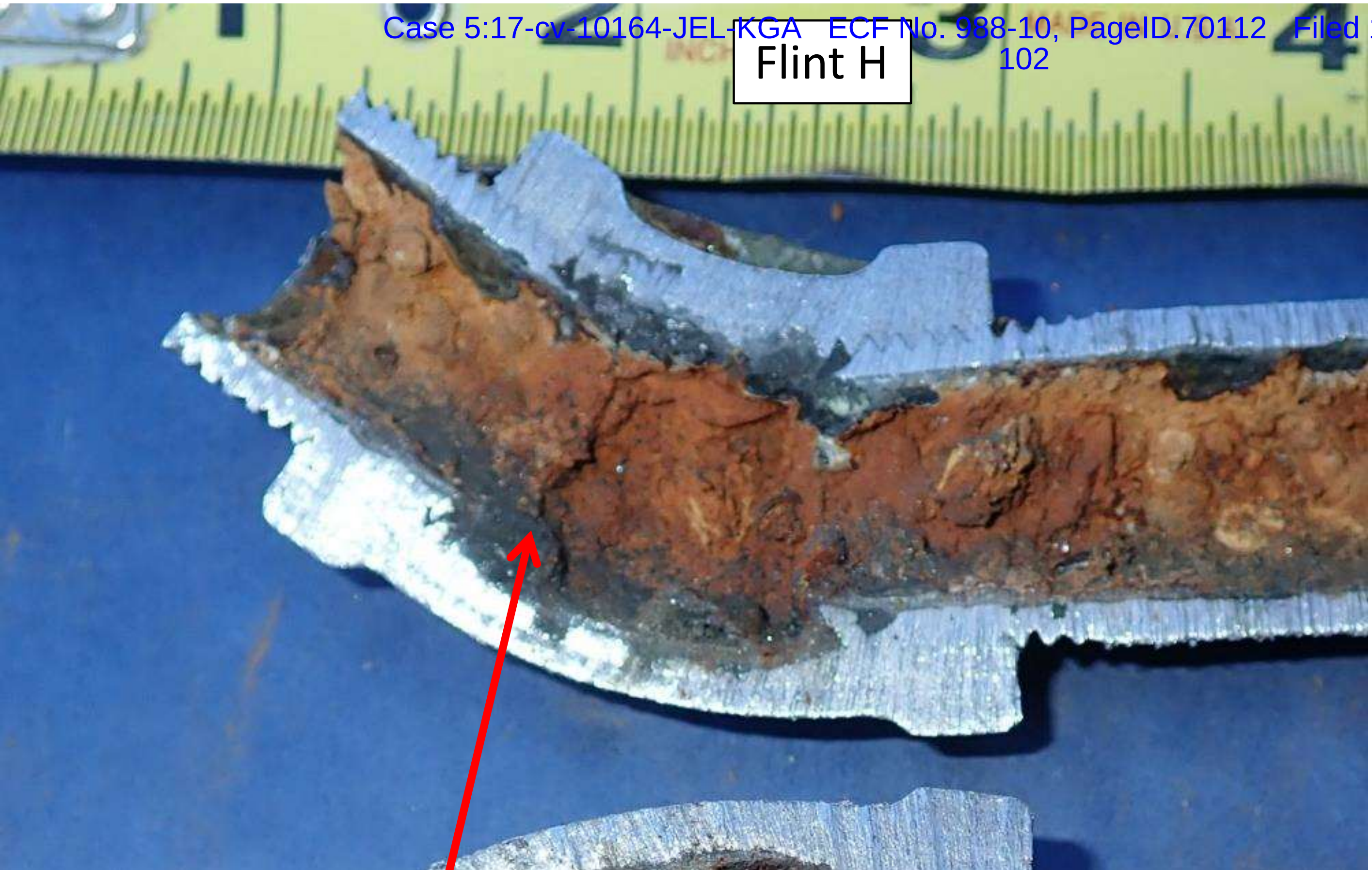


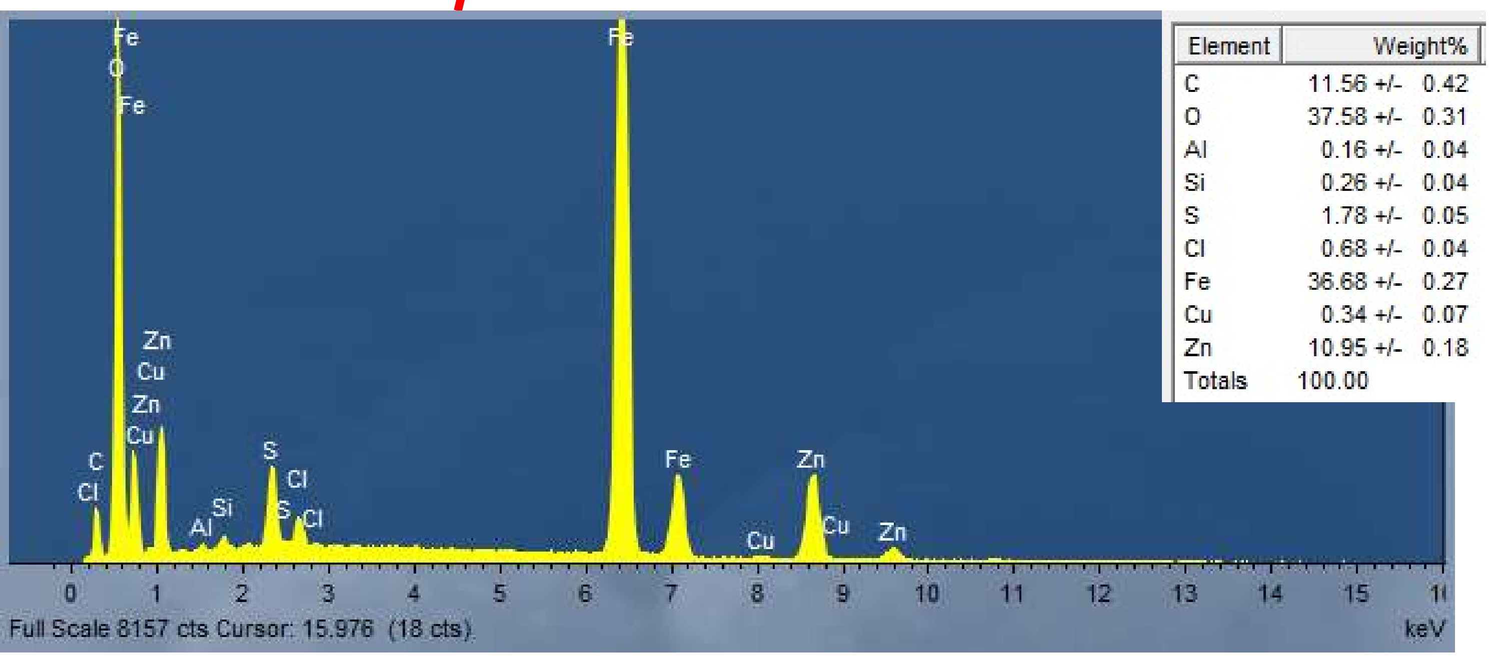
Element	Weight%
C	8.81 +/- 0.53
O	30.88 +/- 0.41
Mg	0.38 +/- 0.08
Al	2.20 +/- 0.09
Si	0.80 +/- 0.07
P	2.16 +/- 0.09
Ca	1.40 +/- 0.06
Mn	0.50 +/- 0.08
Fe	43.60 +/- 0.41
Cu	3.33 +/- 0.16
Zn	5.94 +/- 0.21
Totals	100.00





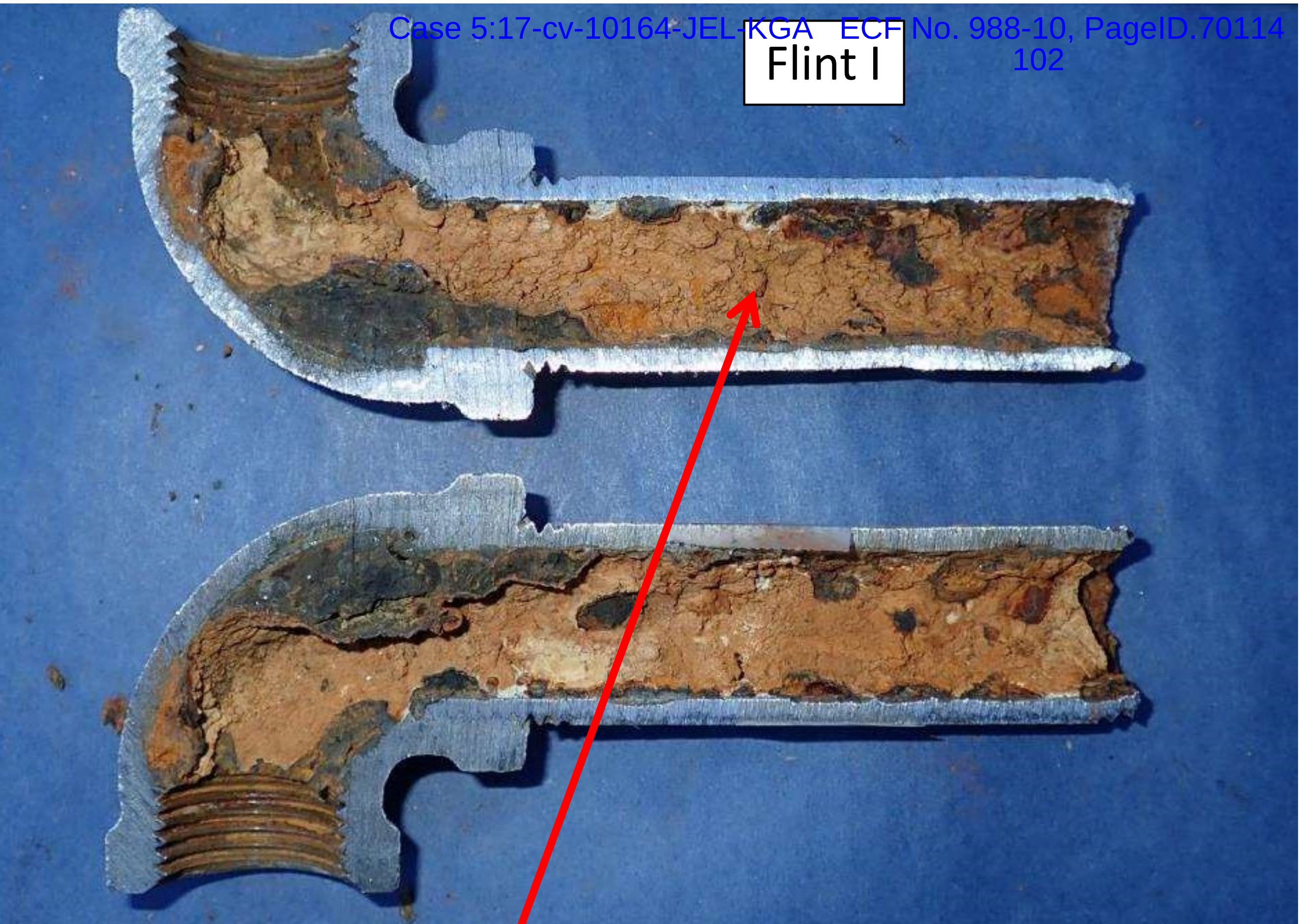
Element	Weight%
C	6.47 +/- 0.41
O	36.97 +/- 0.31
Si	0.34 +/- 0.04
S	2.12 +/- 0.06
Cl	0.65 +/- 0.04
Fe	46.33 +/- 0.32
Cu	0.36 +/- 0.08
Zn	6.76 +/- 0.16
Totals	100.00

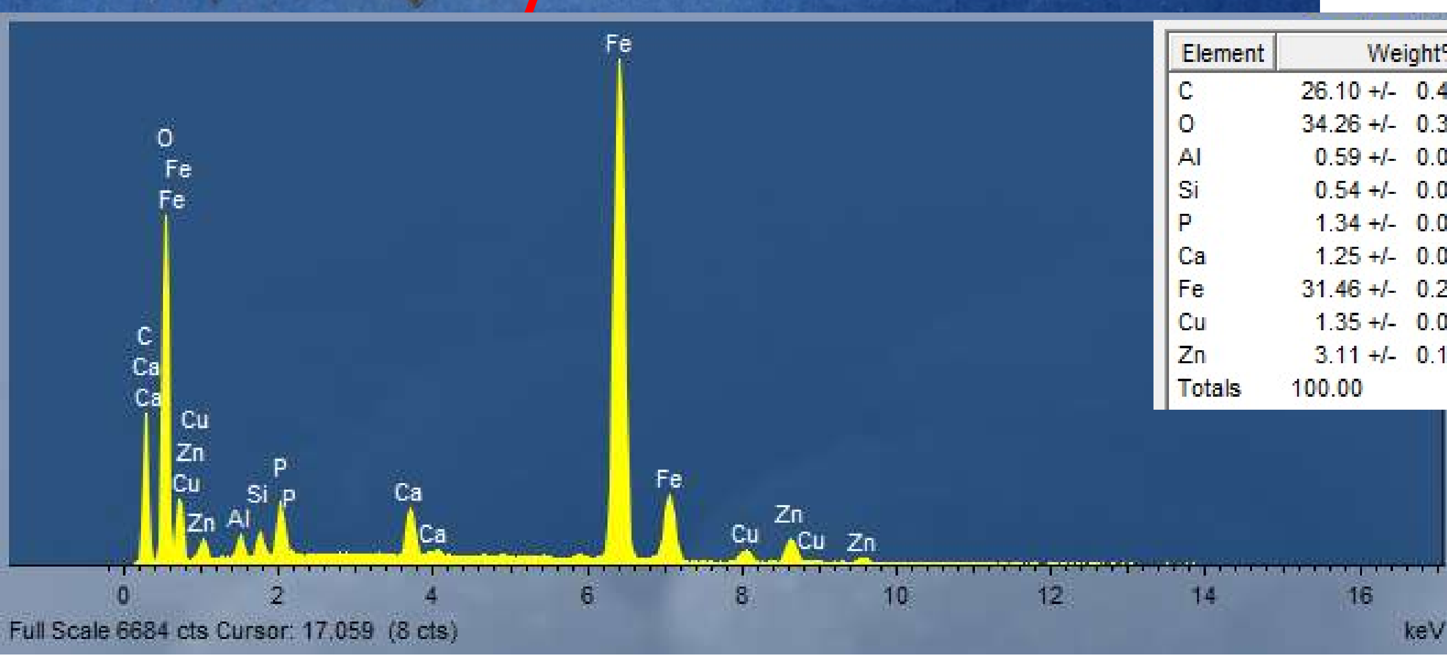




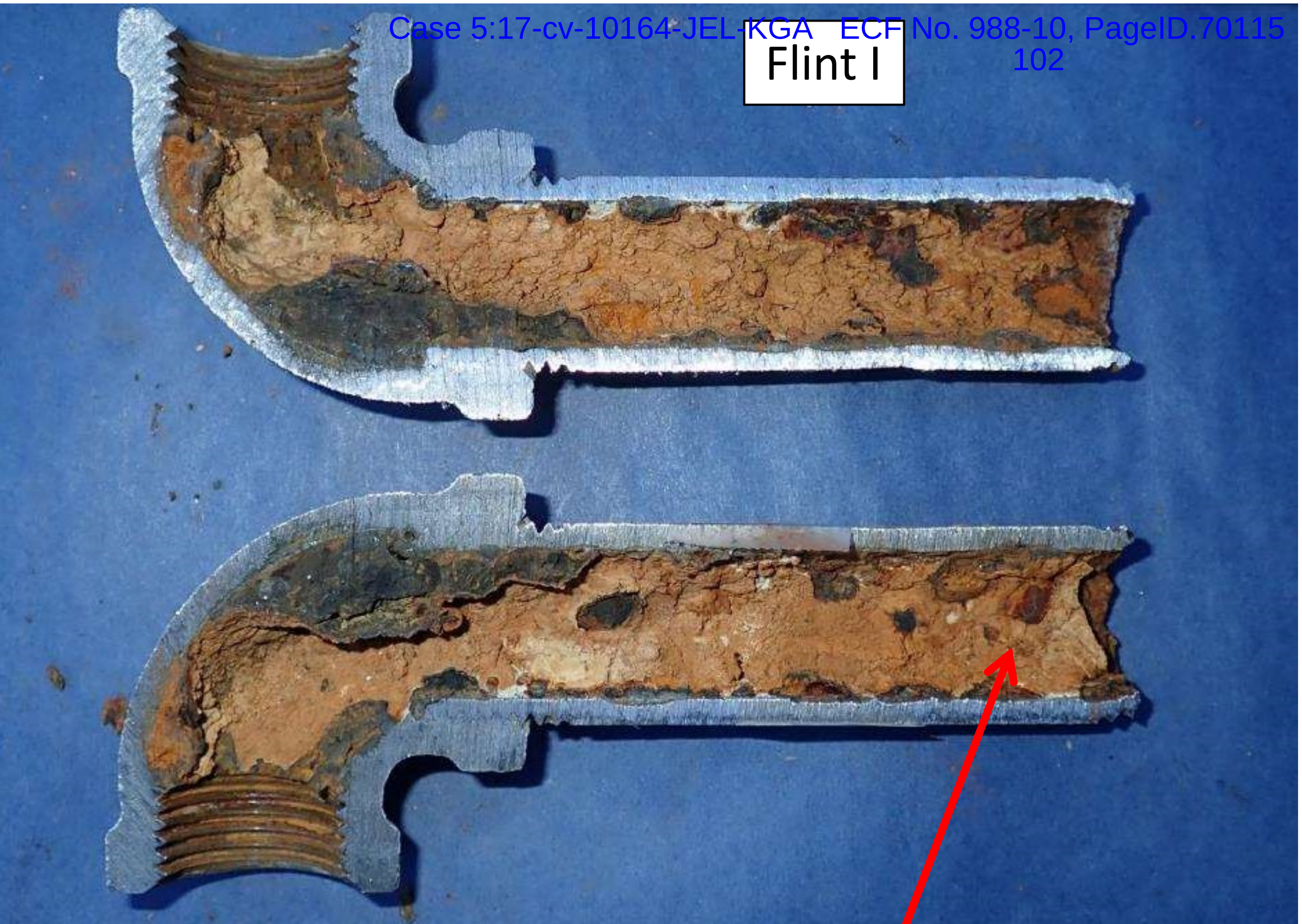
Element	Weight%
C	11.56 +/- 0.42
O	37.58 +/- 0.31
Al	0.16 +/- 0.04
Si	0.26 +/- 0.04
S	1.78 +/- 0.05
Cl	0.68 +/- 0.04
Fe	36.68 +/- 0.27
Cu	0.34 +/- 0.07
Zn	10.95 +/- 0.18
Totals	100.00

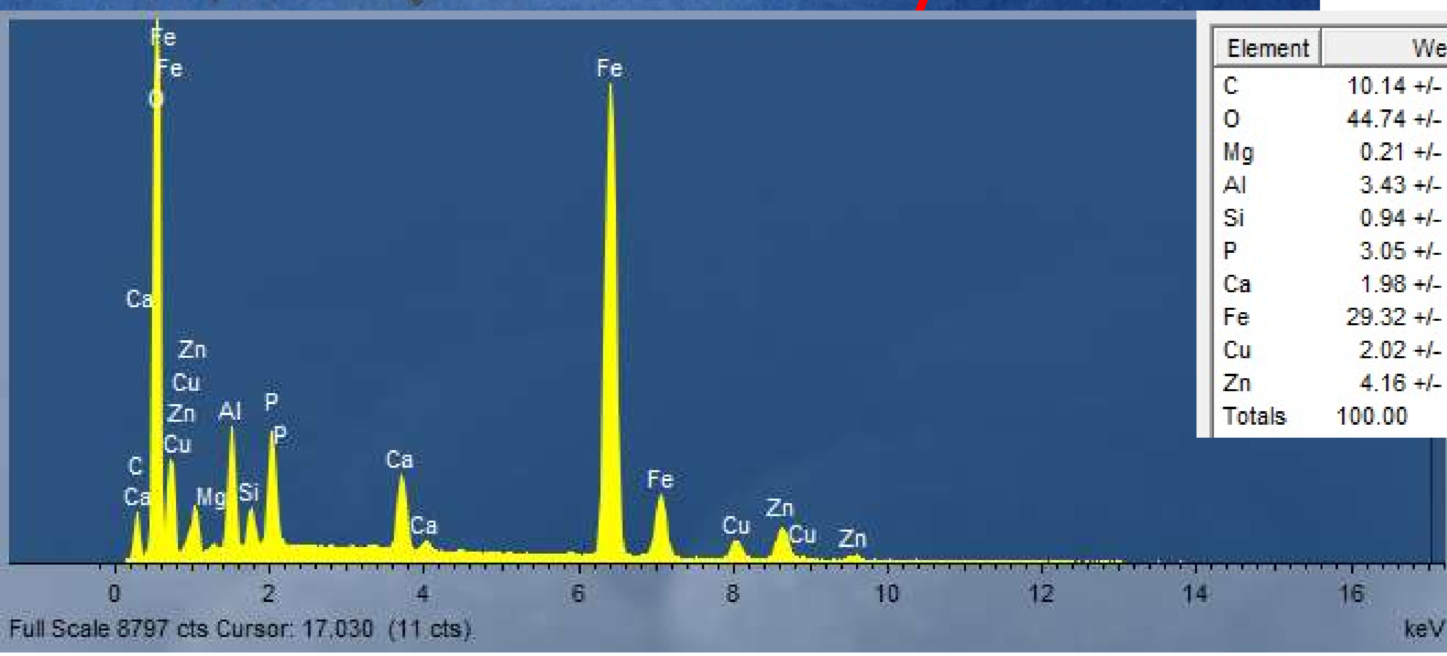
Flint I



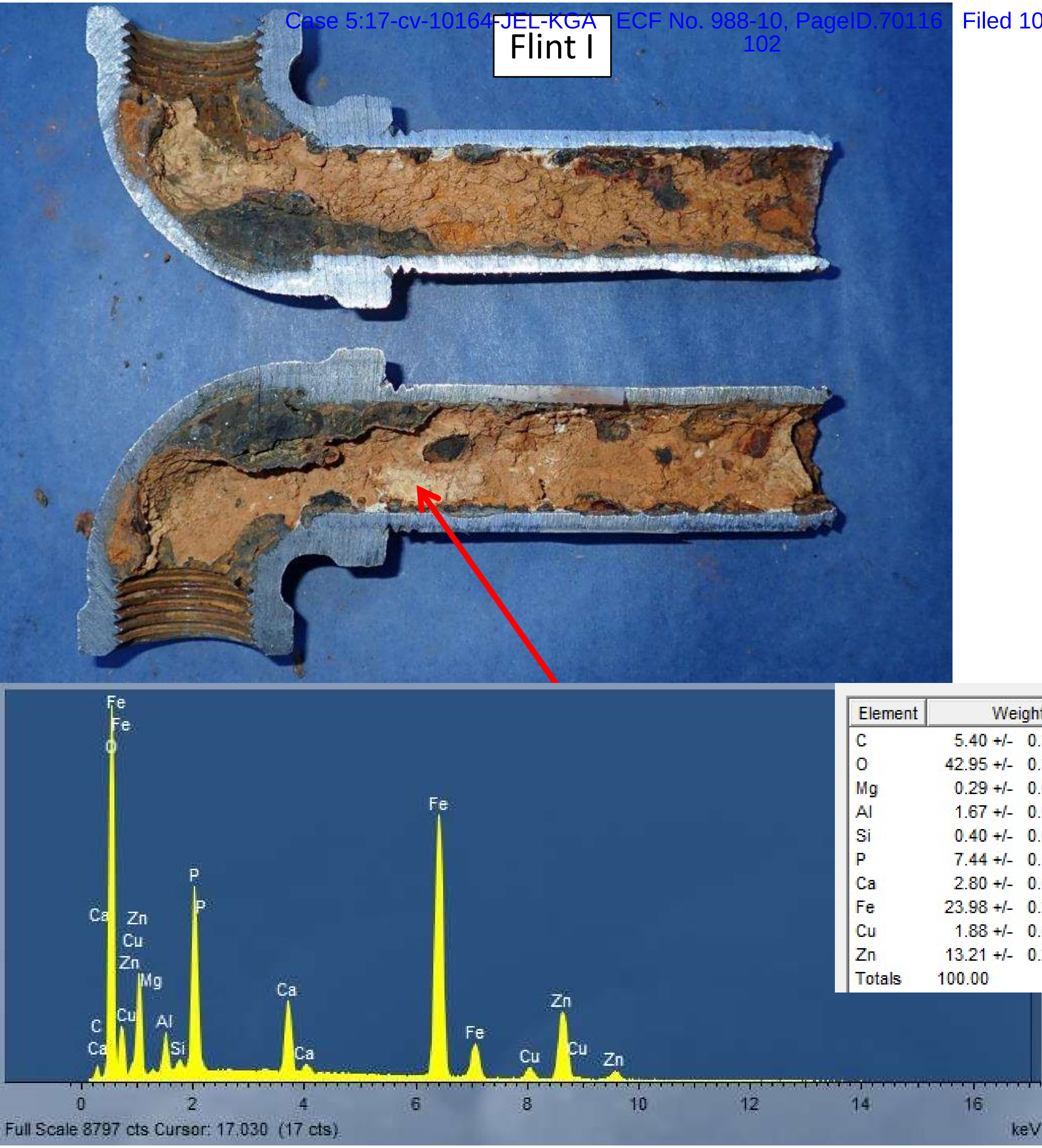


Element	Weight%
C	26.10 +/- 0.45
O	34.26 +/- 0.38
Al	0.59 +/- 0.04
Si	0.54 +/- 0.04
P	1.34 +/- 0.06
Ca	1.25 +/- 0.04
Fe	31.46 +/- 0.29
Cu	1.35 +/- 0.09
Zn	3.11 +/- 0.13
Totals	100.00



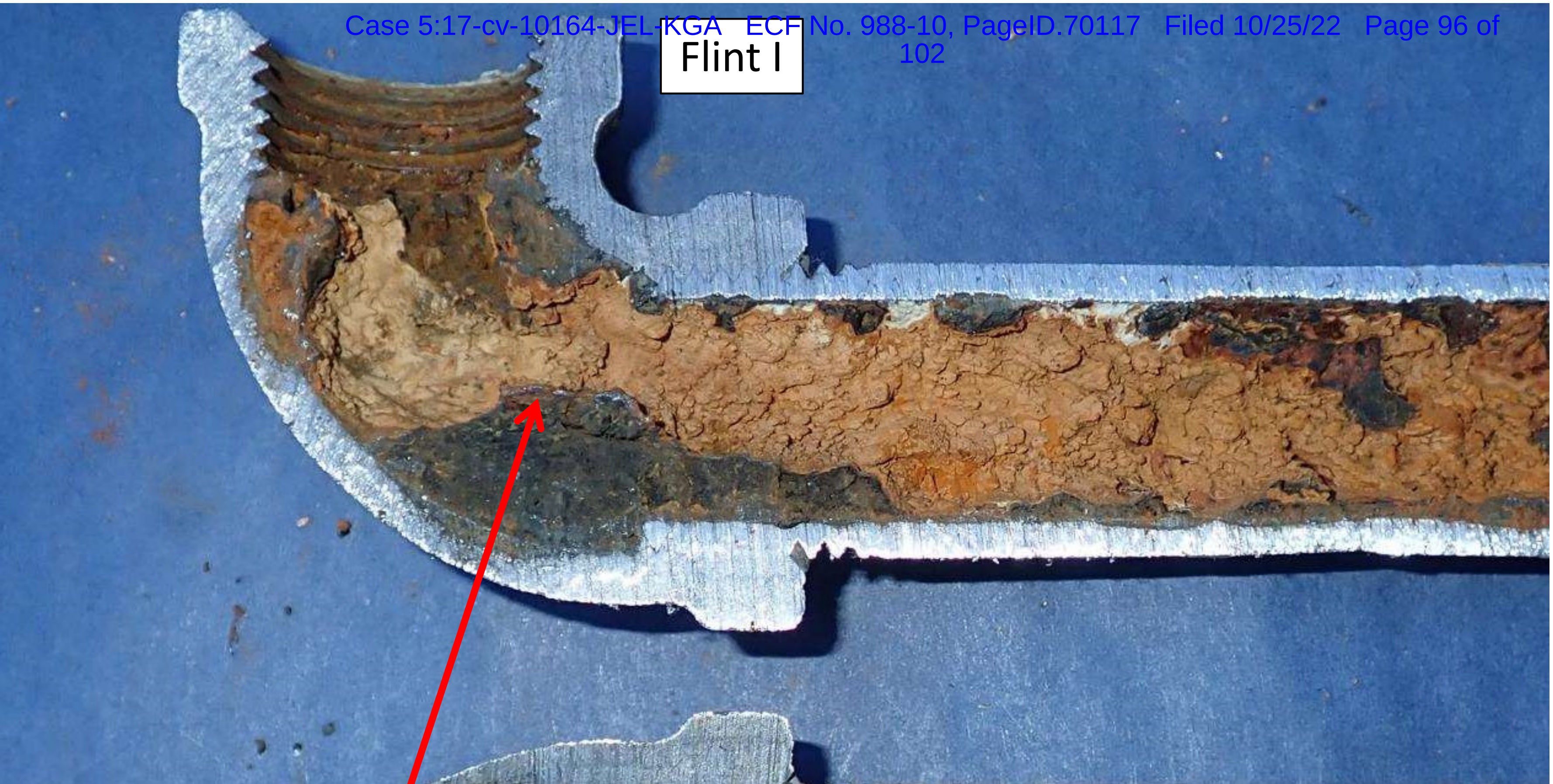


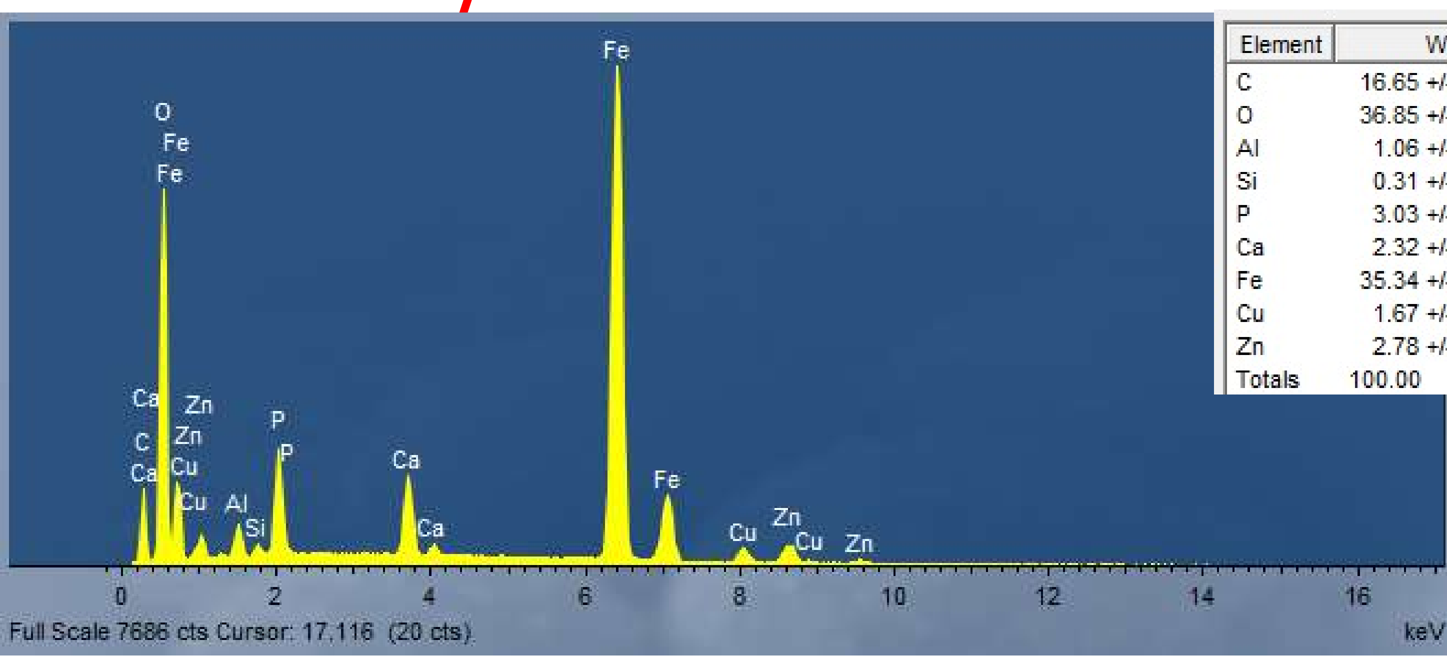
Element	Weight%
C	10.14 +/- 0.38
O	44.74 +/- 0.32
Mg	0.21 +/- 0.05
Al	3.43 +/- 0.08
Si	0.94 +/- 0.05
P	3.05 +/- 0.07
Ca	1.98 +/- 0.05
Fe	29.32 +/- 0.23
Cu	2.02 +/- 0.09
Zn	4.16 +/- 0.13
Totals	100.00



Element	Weight%
C	5.40 +/- 0.38
O	42.95 +/- 0.33
Mg	0.29 +/- 0.06
Al	1.67 +/- 0.07
Si	0.40 +/- 0.05
P	7.44 +/- 0.11
Ca	2.80 +/- 0.06
Fe	23.98 +/- 0.21
Cu	1.88 +/- 0.09
Zn	13.21 +/- 0.20
Totals	100.00

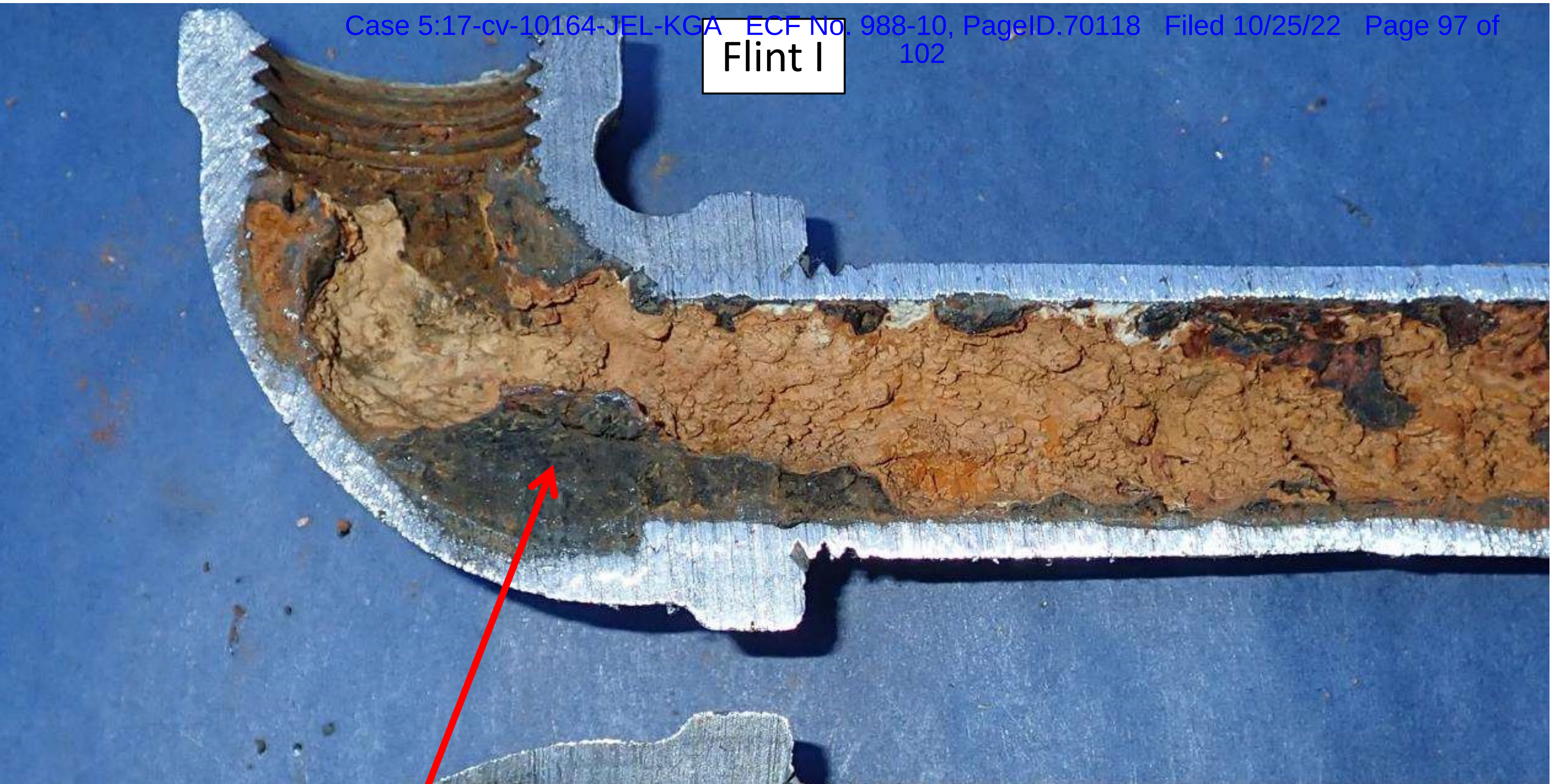
Flint I

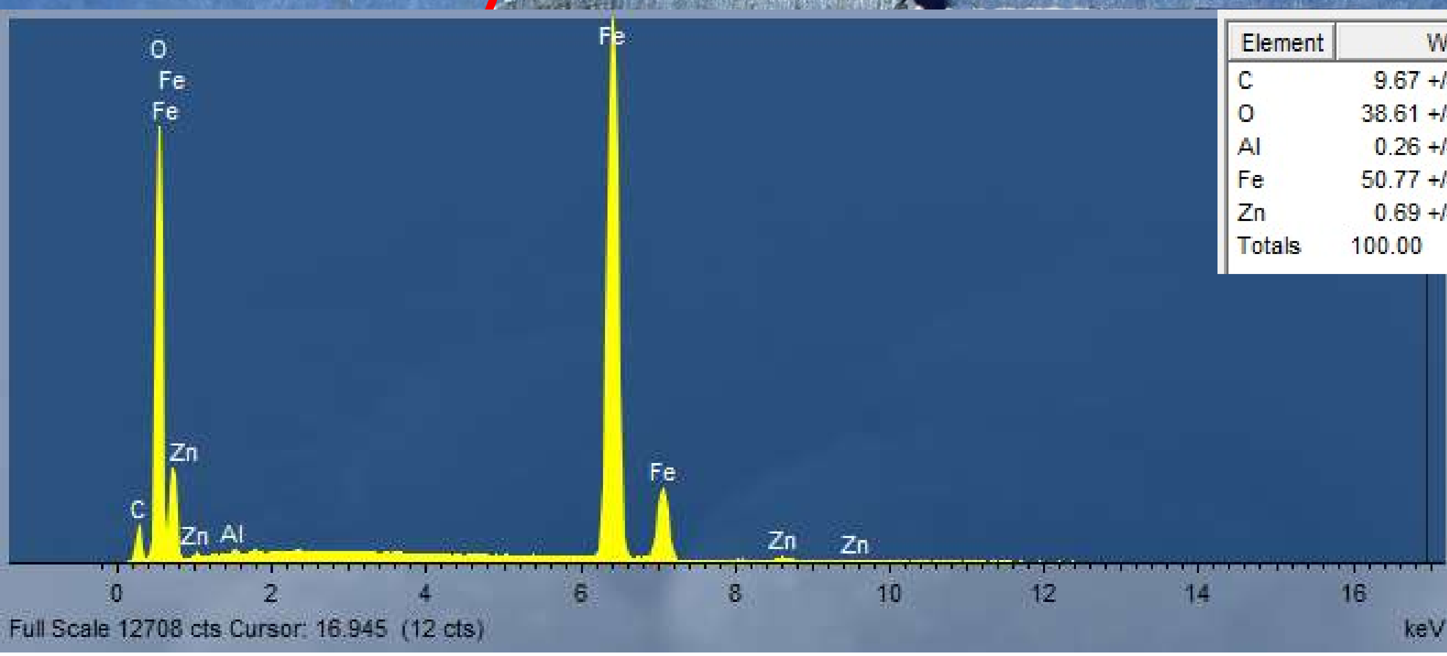




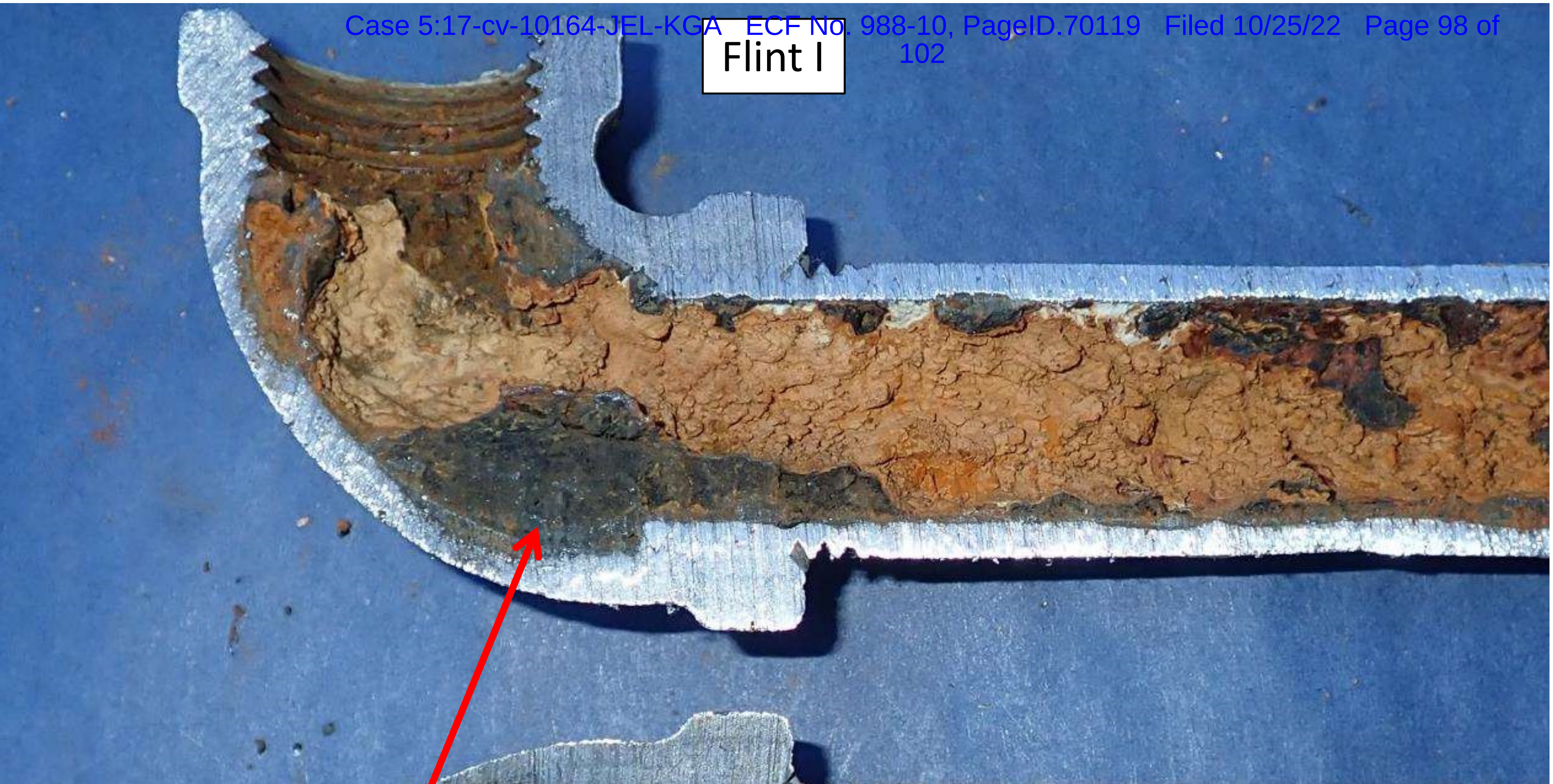
Element	Weight%
C	16.65 +/- 0.45
O	36.85 +/- 0.37
Al	1.06 +/- 0.06
Si	0.31 +/- 0.04
P	3.03 +/- 0.08
Ca	2.32 +/- 0.06
Fe	35.34 +/- 0.30
Cu	1.67 +/- 0.10
Zn	2.78 +/- 0.13
Totals	100.00

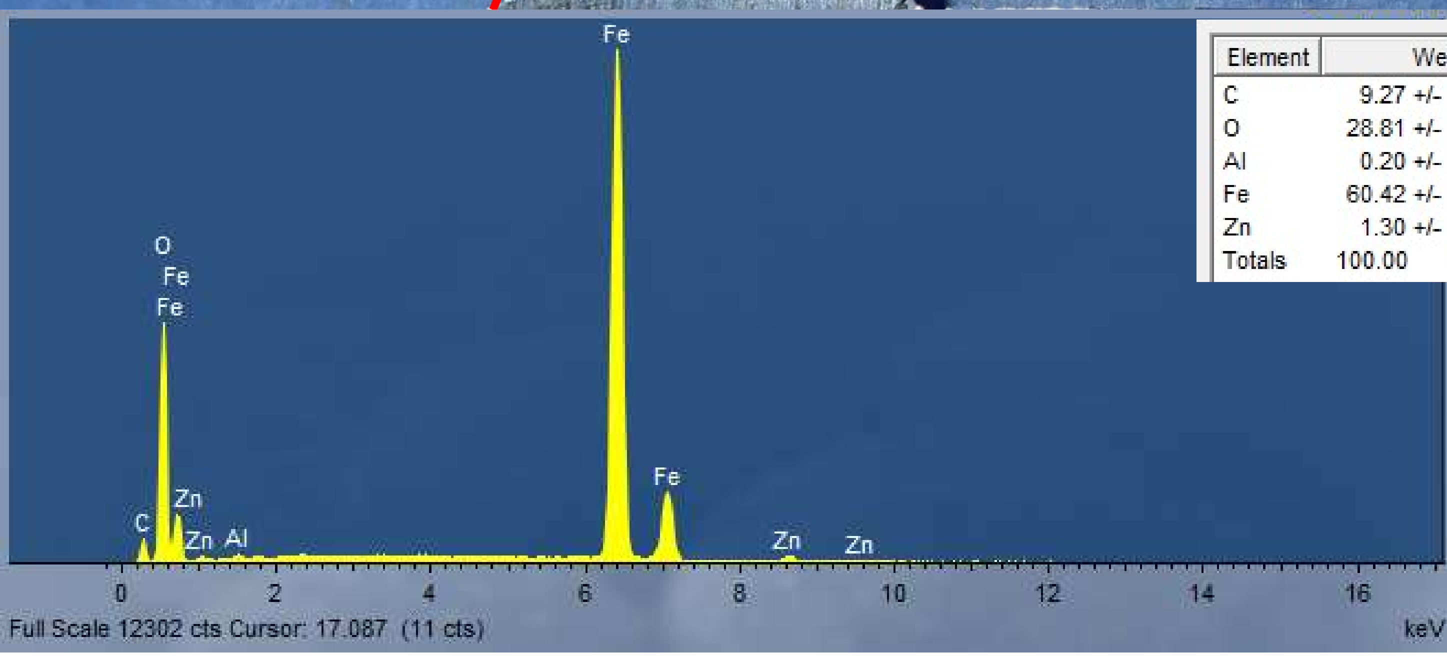
Flint I





Element	Weight%
C	9.67 +/- 0.35
O	38.61 +/- 0.28
Al	0.26 +/- 0.04
Fe	50.77 +/- 0.30
Zn	0.69 +/- 0.09
Totals	100.00





Element	Weight%
C	9.27 +/- 0.40
O	28.81 +/- 0.30
Al	0.20 +/- 0.05
Fe	60.42 +/- 0.37
Zn	1.30 +/- 0.12
Totals	100.00

Attachment 3:

Laboratory Reports on the Interior Scale

A & R Laboratories, Inc.
1650 S. GROVE AVE., SUITE C
ONTARIO, CA 91761
909-781-6335
www.arlaboratories.com office@arlaboratories.com

CHEMISTRY · MICROBIOLOGY · FOOD SAFETY · MOBILE LABORATORIES
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CERTIFICATE OF ANALYSIS

2209-00064

Clinical Laboratory of SB
Stu Styles
21881 Barton Road
Grand Terrace, CA 92313

Date Reported	09/14/22
Date Received	09/08/22
Invoice No.	95870
Cust #	C236
Permit Number	
Customer P.O.	

Project: 22I0337

Analysis	Result	Qual	Units	Method	DF	MDL	RL	Date	Time	Tech
Sample: 001 FLINT C / 22I0337-01 Sample Matrix: **Solid**					Date & Time Sampled:			09/07/22		
Phosphorous, Total	<1.0		mg/Kg	EPA 365.3	1.0	1.0000	5.0	09/13/22	11:30	JEH
[Metals]										
Metals Acid Digestion	Complete			EPA 3050B	1.0			09/12/22	11:29	TLB
Lead	**114**		mg/Kg	EPA 6010B	1.0	0.2300	0.50	09/12/22	11:29	TLB
Sample: 002 FLINT G / 22I0337-02 Sample Matrix: **Solid**					Date & Time Sampled:			09/07/22		
Phosphorous, Total	<1.0		mg/Kg	EPA 365.3	1.0	1.0000	5.0	09/13/22	11:30	JEH
[Metals]										
Metals Acid Digestion	Complete			EPA 3050B	1.0			09/12/22	11:29	TLB
Lead	**41.8**		mg/Kg	EPA 6010B	1.0	0.2300	0.50	09/12/22	11:29	TLB
Sample: 003 FLINT I / 22I0337-03 Sample Matrix: **Solid**					Date & Time Sampled:			09/07/22		
Phosphorous, Total	<1.0		mg/Kg	EPA 365.3	1.0	1.0000	5.0	09/13/22	11:30	JEH
[Metals]										
Metals Acid Digestion	Complete			EPA 3050B	1.0			09/12/22	11:29	TLB
Lead	**83.3**		mg/Kg	EPA 6010B	1.0	0.2300	0.50	09/12/22	11:29	TLB
Sample: 004 FLINT H / 22I0337-04 Sample Matrix: **Solid**					Date & Time Sampled:			09/07/22		
Phosphorous, Total	<1.0		mg/Kg	EPA 365.3	1.0	1.0000	5.0	09/13/22	11:30	JEH
[Metals]										
Metals Acid Digestion	Complete			EPA 3050B	1.0			09/12/22	11:29	TLB
Lead	**168**		mg/Kg	EPA 6010B	1.0	0.2300	0.50	09/12/22	11:29	TLB
Sample: 005 FLINT D / 22I0337-05 Sample Matrix: **Solid**					Date & Time Sampled:			09/07/22		
Phosphorous, Total	<1.0		mg/Kg	EPA 365.3	1.0	1.0000	5.0	09/13/22	11:30	JEH
[Metals]										
Metals Acid Digestion	Complete			EPA 3050B	1.0			09/12/22	11:29	TLB
Lead	**145**		mg/Kg	EPA 6010B	1.0	0.2300	0.50	09/12/22	11:29	TLB

Pace Analytical®
ENVIRONMENTAL SCIENCES

S.O.S. - System Operation Services
200 Martinique Ave
Tiburon, CA 94920

Reported: 03/08/2022 14:52
Project: Water - Non Regulatory
Project Number: REED International
Project Manager: Todd Russell

Water Analysis (General Chemistry)

BCL Sample ID: 2203469-01 | **Client Sample Name:** Flint, 2/11/2022 10:00:00AM

Constituent	Result	Units	PQL	Method	MB Bias	Lab Quals	DCN
Total Recoverable Calcium	**30**	**mg/L**	**0.10**	**EPA-200.7**	ND		1
Total Recoverable Magnesium	**8.6**	**mg/L**	**0.050**	**EPA-200.7**	ND		2
Total Recoverable Sodium	**12**	**mg/L**	**0.50**	**EPA-200.7**	ND		2
Total Recoverable Potassium	**1.1**	**mg/L**	**1.0**	**EPA-200.7**	ND		2
Bicarbonate Alkalinity as CaCO3	**88**	**mg/L**	**4.1**	**SM-2320B**	ND		3
Carbonate Alkalinity as CaCO3	<4.1	mg/L	4.1	SM-2320B	ND		3
Hydroxide Alkalinity as CaCO3	<4.1	mg/L	4.1	SM-2320B	ND		3
Alkalinity as CaCO3	**88**	**mg/L**	**4.1**	**Calc**	ND		4
Chloride	**9.6**	**mg/L**	**0.50**	**EPA-300.0**	ND		5
Fluoride	**0.65**	**mg/L**	**0.050**	**EPA-300.0**	ND		5
Nitrate as N	**0.33**	**mg/L**	**0.10**	**EPA-300.0**	ND	**A26,S05**	5
Sulfate	**25**	**mg/L**	**1.0**	**EPA-300.0**	ND		5
Total Cations	**2.8**	**meq/L**	**0.10**	**Calc**	ND		6
Total Anions	**2.6**	**meq/L**	**0.10**	**Calc**	ND		4
Anion / Cation Balance	**2.5**	**%**	**0.10**	**Calc**	ND		7
Hardness as CaCO3	**110**	**mg/L**	**0.50**	**Calc**	ND		6
Aggressive Index	**11.7**	**NA**	**0**	**Calc**	0	**R_AI-M**	8
Langlier Index	**-0.15**	**NA**	**-2.00**	**Calc**	0	**R_LI-N**	8
Nitrate + Nitrite as N	**0.36**	**mg/L**	**0.10**	**Calc**	ND		9
pH	**7.91**	**pH Units**	**0.05**	**EPA-150.1**		**S05**	10
Electrical Conductivity @ 25 C	**269**	**umhos/cm**	**1.00**	**SM-2510B**			11
Total Dissolved Solids @ 180 C	**140**	**mg/L**	**6.7**	**SM-2540C**	ND		12
MBAS	<0.20	mg/L	0.20	SM-5540C	ND	A10,A26,S05	13
Nitrite as N	<0.050	mg/L	0.050	EPA-353.2	ND	A26,S05	14
Total Phosphate	**2.2**	**mg/L**	**0.15**	**EPA-365.4**	ND		15

Pace Analytical®
ENVIRONMENTAL SCIENCES

S.O.S. - System Operation Services
200 Martinique Ave
Tiburon, CA 94920

Reported: 03/08/2022 14:52
Project: Water - Non Regulatory
Project Number: REED International
Project Manager: Todd Russell

Metals Analysis

BCL Sample ID:	2203469-01	**Client Sample Name:**	Flint, 2/11/2022 10:00:00AM

Constituent	Result	Units	PQL	Method	MB Bias	Lab Quals	DCN
Total Recoverable Copper	**5.0**	**ug/L**	**2.0**	**EPA-200.8**	ND		1
Total Recoverable Lead	<1.0	ug/L	1.0	EPA-200.8	ND		1
Total Recoverable Zinc	<10	ug/L	10	EPA-200.8	ND		1

DCN	Method	Prep Date	Run Date/Time	Analyst	Instrument	Dilution	QC Batch ID	Prep Method
1	EPA-200.8	02/21/22 06:00	02/21/22 12:00	KHS	PE-EL2	1	B132258	EPA 200.2

DCN = Data Continuation Number